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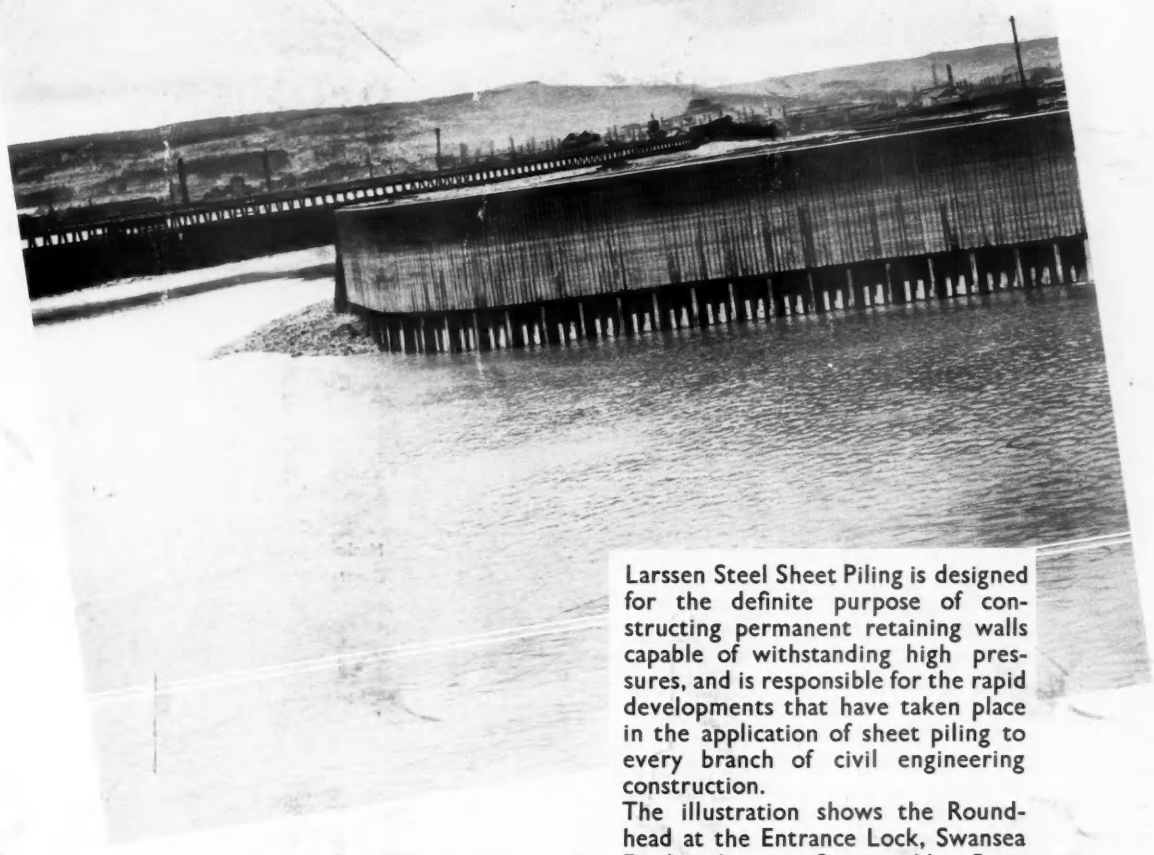

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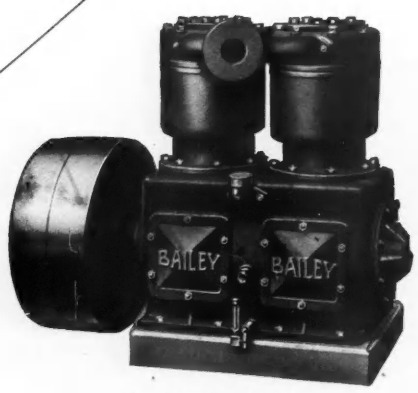

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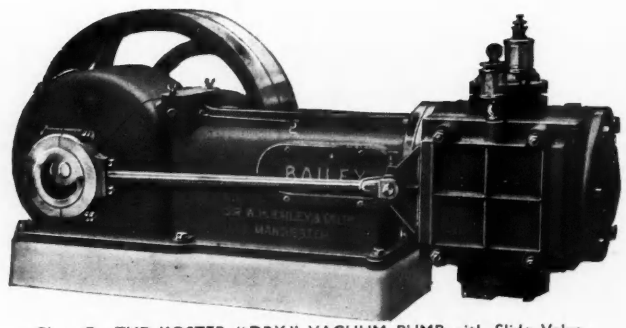

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A Seven-Day Journal

Tyneside Industries.

AT a meeting of representatives of the Tyneside local authorities which was held in Newcastle-upon-Tyne on Thursday, March 28th, the constitution and activities of the proposed Tyne Industrial Development Board were discussed. It was decided that the Board should consist of representatives of subscribing county and other boroughs, local authorities, and companies, and such organisations as might be elected by the Executive Committee, and should be governed by a Council of Representatives of local authorities, subscribing industrialists, trade unions, and various commercial and technical interests. Its functions would include publicity schemes, the reception of visitors interested in industrial development, collection of statistical information, assistance of local authorities and others in their efforts to bring about industrial development, and the maintenance and enhancement of the industrial position of Tyneside. A number of officers were elected, including Commander Sir Charles W. Craven as President, the Lord Mayor of Newcastle, and the Mayors of Gateshead, South Shields, Tynemouth, Wallsend, and Jarrow as Vice-Presidents, and Mr. C. C. Coote as Secretary. A further meeting of the Board is to be held in Newcastle shortly to discuss future plans.

The Retirement of Sir Thomas Bell.

IT is announced by John Brown and Co., Ltd., that Sir Thomas Bell relinquished his office of managing director of the Clydebank shipyard and engineering works as from March 31st, 1935. Sir Thomas will retain his seat on the board. Mr. Stephen J. Pigott, who has been for many years closely associated with the management at Clydebank, and was recently elected to the board of the company, has been appointed resident director. Sir Thomas Bell has been associated with the shipbuilding and engineering industries for over half a century. The last few years of trade depression have been difficult, and now that there is some measure of improvement in industry, we hope that he will enjoy to the full many years of well-deserved leisure. He was born in India in 1865, and is the son of Mr. Imrie Bell, a noted civil engineer. He was educated at King's College and the Royal Naval Engineering College, Devonport. In 1886 he entered the works of James and George Thomson at Clydebank as a draughtsman. The undertaking was later taken over by John Brown and Co., Ltd., and Sir Thomas rapidly rose to a managerial position. He was appointed resident director in 1909, and during part of the war he was Deputy-Controller of Dockyards and Shipbuilding at the Admiralty. In 1917 he was knighted in recognition of his services to the nation. Mr. Pigott, who succeeds Sir Thomas, went to Clydebank some twenty-five years ago, and is a recognised authority on steam turbine design. His wide engineering knowledge and his proved administrative ability should make him a worthy successor to Sir Thomas Bell.

Italy's Air Programme.

THE programme of the Italian Air Force was announced last week by General Vallé, Under Secretary of State for Air, in the Chamber of Deputies. This year, he said, the construction had already been begun of bombers to carry 1500 kilos. of war material. Their range of action was to be 2000 kiloms., and their maximum attainable altitude 8000 m. Next year, construction, he continued, is to be commenced on still larger machines. These are to have a speed of 440 kiloms. per hour, and a "ceiling" of 10,000 m. It is interesting to note the importance attached in Italy to attainable altitude in these bombers. While this quality in a machine is especially important in Italy, owing to the almost invariable necessity of flying over mountains, it is also interesting as it provides so effective an element of surprise to a bombing attack. At such a height anti-aircraft defences are greatly minimised in value, detection of the plane's presence and whereabouts becomes most difficult, and the manœuvring powers of attacking planes are greatly impaired. The technical advances implied by such a performance will be evident when it is realised that the use of oxygen breathing apparatus for the pilots becomes necessary at this height. Naturally, the problems of carburation and of wing design to be surmounted make such a design a noteworthy feat of engineering.

Russian Oil Engine Trial Results.

THE results of the Russian high-speed road transport oil engine trials, which took place on a course of over 5000 kiloms. between Moscow and Tiflis during July to November last year, have now been communicated to the competitors. On Monday last, Mr. Alexander Ozersky, the Chairman of the Russian Trade Delegation, presented to Mr. H. A. Reincke, the chairman of William Beardmore and Co., Ltd., the prize for the British engine which showed the best economical performance, also a special medal to Mr. J. Tough Reid, the Beardmore service engineer, who drove the engine. Other prizes awarded to British competitors, of which there were five—"Beardmore," "Crossley," "National," "Perkins," and "Thornycroft"—included a prize for F. Perkins, Ltd., Diesel engineers, for an engine for a 1¼-ton vehicle, and one for John I. Thornycroft and Co., Ltd., for high qualifications in dynamics. The first prize for the best total qualifications out of forty Russian vehicles engined by fifteen firms representing eight European countries, was gained by the "M.A.N." Nuremberg Works, which entered eight engines, all operating on the direct-injection principle. The second prize was gained by the French firm of "Lilloise des Moteurs." The third and the fourth prizes were gained by the Hungarian firms of "Lang" and "Ganz" respectively, whilst the fifth prize went to the Italian firm of "Fiat." Other prizes included one for reliability and endurance, which was gained by the Swiss firm of "Saurer," while other awards were made to the French firm of "Renault," the German firm of "Kemper," the American firm of "Caterpillar Tractors," and the Soviet firm of "Nati," for oil engines for road transport purposes.

A National School of Foundry Practice.

THE Birmingham Education Committee is to consider a proposal to found a national school of foundry practice. The school, which will receive the support of the British Cast Iron Research Association and of the Board of Education, will be housed in the Birmingham Central Technical College. The site is appropriate, since the school will thus be in touch with a large number of firms who will form the best source from which to draw its pupils. Though completely independent of the Technical College, it is proposed to maintain very close relationship, enabling students to avail themselves of the facilities of both establishments. The school will provide a one-year course for a diploma and a limited number of non-diploma students will be admitted. The pupils will be selected largely from among those who have already had experience in the industry, and who show promise of benefiting by a more specialised theoretical training. The need for such a school has become very apparent since the foundry is still one of the few engineering departments where "rule of thumb" and "practice" are often the principal guides. Metallurgy and heat treatment have become the province of the scientific specialist, whose work has become indispensable in modern practice. Unfortunately, the foundry lags behind, its methods and knowledge being largely that of twenty years ago. Generally, the construction of moulds, the use of new cooling and seasoning methods, new materials for cores and moulds, above all, the design of patterns and the detail of casting design as regards metal flow and strength, are subjects of the first importance all too rarely investigated by the scientist. The proposed new school should certainly fill a gap which should make the chain of scientific construction complete from drawing office to test bed.

A Commercial Laboratory for Edinburgh University.

THE announcement was made on Monday last that a sum of £10,000 had been placed at the disposal of the Edinburgh University by Mr. J. Albert Thomson, the managing director of Brown Brothers and Co., of Rose Bank Ironworks, Edinburgh, in order to establish a commercial laboratory. The gift was made after consultation with the President and members of the Edinburgh Chamber of Commerce, of which Mr. Thomson was President during the period 1921 to 1923. It is considered that the University should adapt itself to the latest and most approved methods of training students for a commercial degree, and that those who aspire to the higher positions in industry should be in a position to obtain an intimate working knowledge adequate to keep pace with the development of business organisation and accountancy. It is also considered necessary that students should acquire a practical knowledge of modern systems of works management and administration, and make themselves familiar with the commercial forms and documents which are now in use in modern industry. The munificent gift of Mr. Thomson, which comes from the head of a leading firm of steering gear and hydraulic engineers, will, it is stated, provide for the immediate equipment and staffing of the new laboratory, but the hope is expressed that the scheme may be developed as further gifts come to hand.

Coal Burning.

ON Thursday, March 28th, Lieut.-Colonel J. H. M. Greenly, the deputy chairman of Babcock and Wilcox, Ltd., was elected Chairman of the Coal Burning Appliance Makers' Association (C.A.M.A.). The retiring Chairman, Mr. H. Teeling Smith, of Smith and Wellstood, Ltd., was elected Deputy Chairman of the Association for the coming year. In the course of his speech, Colonel Greenly referred to the inauguration of the Association, a little over a year ago, and the work which had been done by the Committee and its sub-committee in defining the scope of the industry and the Association's activities within it, and in preparing a schedule of appliances for coal burning which covered every possible application. That schedule and a programme of work was, continued Colonel Greenly, issued to members and prospective members early this year, and the recognition of the manufacture of coal-burning appliances as a separate industry rapidly followed. Although it might be said that gas and electricity, though far more expensive than coal, were making increasing headway for domestic heating and cooking in many parts of the country, Colonel Greenly expressed his belief that the pendulum would swing back and that coal-burning appliances would return to favour. That could be brought about, he said, by improvements in design, by better service, by teaching householders how to get the best results with coal-burning appliances, and by increasing confidence. Modern furnace construction proved that smoke could be abolished.

A High-Speed Experimental Train.

THE London and North-Eastern Railway Company announces that a high-speed train designed to carry a limited number of passengers is to be introduced on its Newcastle–London service on October 1st. The new train is to be named the "Silver Jubilee," and will consist of first and third-class corridor coaches and restaurant cars, with a total seating capacity for 194 persons. The coaches are to be built on the articulated principle and the whole of the train, including the locomotive, is to be of streamlined form. The new train is scheduled to leave Newcastle-upon-Tyne daily, except Saturdays and Sundays, at 10 a.m., arriving at King's Cross at 2 p.m. On the return journey the departure from London will be made at 5.30 p.m. and Newcastle will be reached at 9.30 p.m. One stop, at Darlington, with connections for Middlesbrough, Stockton, and Hartlepool, will be made in each direction. The train will be available for ordinary ticket-holders, but, owing to its special character and the limited accommodation available, a small supplementary charge will be made. The train, it is announced, is of the nature of an experiment in order to ascertain whether the public demand for such limited services of a high-speed character is sufficient to warrant their provision as a permanent item in the railway time-table.

New Naval and Mercantile Orders.

AN order for foreign naval vessels, costing about £900,000, has been placed with J. Samuel White and Co., Ltd., of Cowes, by the Polish Government. The order, which was secured in face of intense international competition, is for two powerful destroyers to work as flotilla leaders, which will probably be the largest craft of the type yet built in this country for a foreign Government. The contract is further noteworthy in that it is, we believe, one of the first Polish orders to be placed with a British firm. The overall length of the new ships will be about 374ft., with a beam of 37ft., and a displacement of over 2000 tons. The destroyers will incorporate the latest features in hull and propelling machinery design, and are to be delivered in about twenty-six months. At the end of March the Lord Runciman Shipping Company was formed to acquire a motor vessel which is now under construction at the Pallion Yard of William Doxford and Sons. An interesting order for a motor passenger launch has been placed by the London, Midland and Scottish Railway Company with William Denny and Brothers, Ltd., of Dumbarton. The ship will have accommodation for about sixty passengers, and will operate on the Millport–Fairlie service. She will be electrically welded, and her propelling machinery will comprise two four-cylinder 48 b.h.p. Gleniffer oil engines with reducing gears. Other Clydeside orders placed during the week include a 250ft. motor ship for the Indian Coastal Service of the Bombay Steam Navigation Company, Ltd., which will be built at Govan. At Bowling, Scott and Sons are to build a 175ft. ship for the Canterbury Steam Shipping of New Zealand. At Renfrew, Lobnitz and Co., Ltd., are to construct a powerful tug for the Auckland Harbour Board, of New Zealand, while at the neighbouring yard of Simons and Co., Ltd., a new diving bell barge is to be built for the Clyde Navigation Trust, and will be used for dredging the Clyde before the "Queen Mary" passes down.

The Mauretania and Leviathan.

ON Wednesday, April 3rd, the announcement was made that the Cunard White Star liner "Mauretania" had been purchased by Metal Industries, Ltd., Glasgow, for breaking-up purposes. Her breaking-up value has been estimated at about £80,000. The liner will be broken up for scrap at Rosyth, where the White Star liner "Calgaric" is at present being dismantled for scrap. The firm of Metal Industries, Ltd., was responsible for the breaking up of the salved ships from the German sunken fleet at Scapa Flow. The statement is made that the United States Lines liner "Leviathan" is to be retired from active service. The ship was built in 1914 by Blohm and Voss, in Hamburg, for the Hamburg-Amerika Line, and was named the "Vaterland." She was interned in New York during the war. She was reconditioned and was the flagship of the United States Lines fleet until 1933. Last year she was recommissioned, but has been run at a heavy loss as she failed to compete with the more recently built 30,000-ton cabin-class liners "Manhattan" and "Washington."

Hydro-Electric Power Plant at Cardano.

No. II.

(Concluded from page 336, March 29th.)

THE POWER-HOUSE.

THE power-house is a concrete building with a frontage of 120 m. and a height of 18 m.—see view in page 330 (*ante*). The machinery hall occupies the whole length, and has a clear width of 13 m. The central part contains offices and stores on the ground floor, the cable and secondary switch-rooms on the first floor, and the main switch-room on the second floor. The five generators for industrial, and the three for railway supply are already installed in the great hall, and space is left for a fourth generator for traction service—see Fig. 13, page 358.

In view of the considerable difference of level between the tail race and the ground, the installation of horizontal axis turbines, which are preferably used in Italy, would have presented considerable difficulties on account of the resulting suction head of 6 m. to 7 m. This circumstance and also the prospects of obtaining a higher output (2 per cent.) led to the choice of vertical turbines.

The five Francis turbines for industrial supply are constructed to the following specification :—Maximum horse-power, 45,000; normal horse-power, 41,000; maximum flow, 25 cubic metres per second; normal, 22·5 cubic metres per second; 252–300 revolutions for 42–50 cycles; static head, 155 m. The maximum suction head is 4 m. The admission of the water is regulated by twenty pivoted guide vanes, which are connected by levers and links with the control ring. The cast bronze runner weighs 8000 kilos., and is fitted with a conical stabiliser protruding into the draught tube, and with a balancing ring. The wheel can be dismounted and extracted from below by removing the first section of the draught tube.

The weight of the rotating parts of the turbine, of the alternator and exciter, increased by the hydraulic thrust on the wheel, totals 200 tons, and is carried by a Michell thrust bearing placed in a water-cooled oil tank at the summit of the alternator.

The pressure control or relief valve is placed on the side of the spiral casing, opposite the inflow; it is operated by the governor and a hydraulic servo-motor. The valve opens rapidly when the turbine shuts down and closes slowly, a special braking device being fitted for the purpose.

The governors are installed in the generator hall near the alternators on a special platform, and comprise the usual centrifugal governor, floating lever mechanism, relay, and the various organs for control. The change of speed corresponding to the two periodicities 42 and 50 is effected by modifying the transmission between the motor shaft and the centrifugal governor.

The oil reservoir is placed below the floor and is surmounted by a steel compressed air chamber, and equipped with an efficient water cooling system. It contains a rotary pump, which is operated by a 30 h.p. Pelton turbine fed by a special branch line from the main pipes. As reserve a 30 h.p. electric motor has been installed. The pump is driven by chain at 500 revolutions, and has a capacity of about 2 gallons per second. The normal pressure in the air chamber is 10–12 atmospheres.

In a corridor below the generator room and near each spiral casing two servo-motors, which control the regulator ring, are placed. They are fed by the oil under pressure in the air chamber. Various safety devices are also installed here.

The turbine shaft has a diameter of 600 mm. (23⅝in.). Its upper end is flanged for coupling it with the flanged end of the generator shaft.

Hydraulic Machinery for Railway Traction.—The peculiar conditions of the electrified portion of the Brenner line, which at the time of construction had a length of only 50 miles, necessitated the adoption of Pelton turbines. In fact, whereas frequent cases of no load occurred, when no train was in movement on the line, in other instances the peak load often reached, on account of the heavy gradients of the line, seven times the average load.

Three sets, of which one is reserve, have been installed, with a maximum capacity of 14,700 h.p each at 250 revolutions. Turbines Nos. 7 and 8 were built by one firm; No. 6 by another. One firm adopted four jets with deflectors; the other five jets and substituted synchronous discharge for the deflectors. In both cases equally good results were obtained, the output at the normal average of 2500 h.p. being 80 per cent. The wheels are only 1·50 m. (4ft. 11in.) above maximum level of the tail race, and in order to prevent a sudden synchronous discharge from causing a heavy backwash, the tail race opens into that of the Francis turbines.

In order to obtain a satisfactory efficiency at all stages between 2000 h.p. and the maximum of 14,700 h.p., the flow through the nozzles in the four-nozzle turbines is arranged for the following alternatives :—(*a*) Three jets only, (*b*) four jets, (*c*) three jets at equal volume; when these have reached a predetermined value the fourth jet is opened.

In the five-nozzle turbine, No. 6, the load and speed regulation is effected by means of needle valves, three of which are always controlled by levers and links connected with the governor, whilst two are controlled by a hydraulic device. In the event of excessive speed, a safety device mounted on the main shaft closes electrically the main water valve and shuts the turbine down. No deflectors are used in this turbine. In order to keep the over-pressure due to water hammer within prescribed limits, an automatic slow-closing discharge controlled by the governor has been adopted. It is fitted with a device for maintaining a constant flow at any load.

ELECTRICAL INSTALLATION.

The five alternators with their transformers and switchgear were constructed by two firms; Nos. 1, 2, and 3 by one firm, 4 and 5 by another. At the time of their construction they were the biggest units built in Europe to be driven by water turbines.

FIG. 11—CONTROL ROOM

Electrical Data.—Alternators.

kVA.	Voltage.	Power factor, cos φ.	Frequency.
36,000	10,000—5%	0·8 lag	42–50
36,000	11,000	0·9 lag	50
32,000	10,000—5%	0·5 lag	42–50
28,000	10,000—5%	0·0 lag	42–50
28,000	8,000	0·0 lead	42–50

Constructional Details.

	1, 2, and 3.	4 and 5.
External diameter	6900 mm. (22ft. 7⅛in.)	6800 mm. (22ft. 3⅝in.)
Height above the floor	9000 mm. (29ft. 6⅛in.)	7200 mm. 23ft. 7⅛in.)
Internal diameter of stator	4200 mm. (13ft. 9⅛in.)	4200 mm. (13ft. 9⅛in.)
Length of stator	2280 mm. (7ft. 5⅝in.)	1550 mm. (5ft. 1in.)
Total weight	300 tons	320 tons
Weight of rotating part	130 tons	160 tons
P D² kg./sq. m.	1,100,000 (225,000 lb. per square foot)	1,100,000
Diameter of shaft	703 mm. (27⅝in.)	650 mm. (25⅝in.)
Volume of cooling air at 50 cycles cu. m./sec.	60	60

The alternators have been constructed so as to permit the extraction of the rotor with the upper frame and guide shaft and with the main exciter of a total weight of 200 tons without the necessity of dismantling. For rapid shutting down air brakes acting on the rotor are fitted. The air is supplied from the air chamber of the governor.

The rotors of machines 1, 2, and 3 are composed of four cast steel spiders mounted one above the other and carrying at the periphery magnetic steel rings, on which the windings, when completed, are bolted. The rotor of 4 and 5 is composed of two spiders of similar construction. The laminated poles are mounted in T slots. In 1, 2, and 3 paper insulation is used, and in 4 and 5 the stampings are hot varnished, but without paper insulation. The slots are open. In 1, 2, and 3 each slot contains one conductor composed of multiple wires crossed in the slot; in 4 and 5 each slot holds three conductors of multiple parallel wires, which are crossed at the end connections. For functioning at 50 cycles part of the stator windings and of the main exciter windings are cut out by special commutators.

At each extremity of the windings facing the star or the terminals a series step-down transformer is inserted, which is placed inside the alternator. These transformers feed the metering and protection instruments. The guide bearings are lubricated by a special pump operated through gear drive by the small turbine of the oil pump of the speed governor.

Ventilation air is drawn from the basement and distributed through two ducts entering in the lower and the upper part. The hot air issuing from the periphery of the stator is discharged outside through a duct built between the alternator and the wall and a flue within the wall. By means of a patented device of interconnected valves it is possible to regulate the influx of cold air and to convey part of the hot air into the cold air duct. By the same device the hot air can be let out into the hall to warm the building. A second system of valves, independent from the former, is operated by a differential protection relay which acts in case of damage to the alternator by freeing a counterweight and causing the closing of the inlet and outlet air valves and the opening of the communication valve between the hot and cold ducts; the air circulates in this case within the alternator in a closed circuit. Simultaneously with the closing of the ventilation valves, the valves of eight cylinders containing CO_2 are opened, allowing the discharge of the gas into the interior of the alternator in order to extinguish almost immediately any outbreak of fire due to damage in the windings.

Alternators for Railway Traction.—The electrical data are :—For continuous service, 9000 kVA at 4000 V±6 per cent., 1300 A±6 per cent., and cos φ=0·5÷0·75; periodicity, 16⅔ cycles. The groups can be overloaded twice per hour for two minutes each time up to 13,500 kVA at cos φ=0·75 without dangerous overheating and without decrease of voltage, or four times per hour, five minutes each time, up to 11,250 kVA at cos φ=0·75.

Constructional Details.

External diameter of alternator	6280 mm. (20ft. 7⅛in.)
Height above floor	5400 mm. (17ft. 8⅛in.)
Internal diameter of stator	3800 mm. (12ft. 5⅛in.)
Length of stator	520 mm. (20½in.)
Diameter of shaft	500 mm. (19⅝in.)
Total weight	120 tons
Weight of rotor	66 tons
Cooling air	16 cu. m. /sec. (565 cu. ft.)

The construction is similar to that of 4 and 5, with the difference that the stator rests directly on the frame of the turbine and the shaft is common to turbine and alternator, the Pelton wheel being directly attached to the lower end of the shaft.

9. OUTSIDE ELECTRICAL INSTALLATION.

(*a*) 235-*kV Installation.*—At the time of construction no plants of such a high tension as 235 kV had been constructed in Europe. In America several 220-kV plants were in existence, from which some experience could be gained. At the outset two essential questions had to be solved :—insulated neutral or earthed; single-phase or three-phase transformers.

The plant was built to function either with the neutral insulated or earthed, but from the beginning it has always worked with the neutral earthed. It was also made possible to insert the blow-out coils between neutral and earth, although this system is not favourably looked upon in Italy, whereas it is largely used in Germany.

The second problem was solved by the choice of three-phase transformers of the same capacity as the alternator and normally connected with it, as used elsewhere in Italy in numerous plants of 135 kV.

The general lay-out of the installation can be seen from Fig. 12, page 358.

Two groups function normally at 135 kV and 42 cycles with high-tension windings of the transformer with delta connection, and feed the line to

Feltre and Venice. Provisions have been made to increase the voltage to 235 kV by star connection of the transformer windings. The other groups feed the line at 235 kV. This line runs to Cislago and continues to Turin. Distribution bus-bars for 10,000 volts installed in the basement of the power-house permit the connection of one alternator with any other. On the high-tension line there is only one system of bus-bars, with section switches.

In the general lay-out of the installation the Cardano plant shows an original departure from the usual American type, the only one then in existence, with its enormous trelliced steel constructions. The Italian engineers, with their inborn artistic sense, have shown also on this occasion that technical constructions need not always destroy the æsthetic aspect.

A horizontal development of the installation with the system of wires suspended from insulator chains was opposed on account of the restricted space and the great number of insulators which would have been required. A new system was therefore adopted with horizontal development, where the individual parts—transformer, isolator, circuit breaker—are placed near one another, the connections resting only on the terminals of the apparatus. In this way the intermediate carrying insulators and the steel framework to support them became unnecessary.

In the whole installation, comprising five transformers and two outgoing trunk lines, only seventeen supporting insulators, which do not form part of an apparatus, are to be found. The whole installation, as will be seen from Fig. 12, has thus become remarkably simple.

The rails for the transport of the apparatus are differently disposed from the usual practice, as the transformers and oil switches have to be moved sideways to convey them to a traverser. This last consists of two easily coupled bogies, the wheels of which can be placed in either direction.

The bus-bars are kept at a low height and they are placed within an enclosure to prevent access. Two underground passages connect the parts of the installation which are divided by the enclosure.

The Transformers.

Technical details	Nos. 1, 2, 3.	Nos. 4, 5.
Capacity	36,000 kVA	36,000 kVA
Voltage, primary	10,000 volts	10,000 volts
Voltage, secondary	229,500 volts	228,200 volts
Cycles	42–50	42–50
Total height	9·220 m. (30ft. 3in.)	10·00 m. (32ft. 9in.)
Height of casing	6·650 m. (21ft. 9⅝in.)	5·290 m. (17ft. 0⅜in.)
Length	7·36 m. (24ft. 1⅝in.)	6·50 m. (21ft. 3⅞in.)
Depth	3·14 m. (10ft. 3⅝in.)	3·34 m. (10ft. 11⅛in.)
Total weight including oil	168 tons	150 tons
Weight of core with windings	80 tons	70 tons
Weight of oil	57	65

The conductors between the alternator and the transformer are of unprotected copper bars of the total section of 1600 square millimetres (1·48in.) and run in underground ducts. They reach the transformer passing through a steel casing attached to the framework, which supports the expansion chamber and the oil pump. The oil circulates in finned radiators in a metal tank, which has on one side a shutter, through which the cold air is forced by a fan driven by a 27 h.p. motor equipped with an automatic centrifugal starter mounted in the rotor. The oil pump and ventilator motors are remote controlled from the main switch room.

All transformers are fitted with a rapid oil emptying device for cases of fire, the outlet valves of which are of the oil pressure servo-motor type and are remote controlled. The oil switches and traction transformers have the same remote controlled emptying device.

All the transformers of the two firms are of the three-core type, closed at both ends by the yokes, with concentric windings. The pole cores are made up bundles of stampings 0·4 mm. thick, suitably spaced for the circulation of oil. In 1, 2, and 3 the stampings are insulated by paper; in 4 and 5 hot varnished stampings without paper are used. The high-tension terminals—three for the phases and one for the neutral—are of the usual type with a series of insulating cylinders protected by a brown porcelain oil-filled tube. The porcelain shell is made in one piece and has a height of 2·20 m. (7ft. 2⅝in.).

The Oil Switches.—The switches 4 and 5 are of the double-break type with explosion chamber, whilst 1, 2, and 3 are of the usual multiple spherical contact type. The terminals are identical with those of the transformers, with the exception that they are equipped with instrument transformers for the ammeters and the maximum current relays.

Technical details	1, 2, 3.	4, 5.
Height	7·60 m. (24ft. 11⅛in.	6·995 m. (23ft. 11⅛in.)
Diameter of oil tank	2·80 m. (9ft. 2⅛in.)	2·780 m. (9ft. 1⅛in.)
Height of oil tank	4·44 m. (14ft. 6⅝in.)	4·00 m. (13ft. 1⅛in.)
Distance between terminals of same pole, ext.	2·620 m. (8ft. 7⅛in.)	3·560 m. (11ft. 8⅛in.)
Distance between centres of the three poles	3·500 m. (11ft. 5⅜in.)	3·500 m. (11ft. 5⅜in.)
Weight of three poles including controller and oil	98 tons	89 tons
Guaranteed rupturing capacity	2,000,000 kVA	1,500,000 kVA
Test voltage to frame	500,000 volts	500,000 volts
Test voltage to frame in rain	450,000 volts	450,000 volts

The Isolators.—These are of the three-pillar type with rotating central pillar carrying the contact arm. The distance between the outer pillars is 3·50 m. (11ft. 5⅜in.), the height of the carrying pillar 2·50 m. (8ft. 2⅜in.). The separation is 1·80 m. (5ft. 10⅞in.) between the contacts of the rotating arm in the open position and the fixed parts. The contacts are constructed for 500 ampères at service voltage and consist of movable bushes. The fixed contact is of bronze with a flat vertical surface protected by a cap. The carrying pillars consist of five extra strong insulators of the four-piece delta type. They weigh 250 kilos. and are tested for 690 kV dry and 450 kW wet. The isolators can be operated by hand or from the main switchboard room.

Conductors.—The connection between the transformer switches and the first series of the blades consists of a copper tube of 50 mm. diameter. For the high-tension bus-bars and their branches steel tubes of 90 mm. external and 80 mm. internal diameter have been adopted on account of the intervening distances of 8 m. and 16 m. The distance between the conductors of different phase has been kept at 4·50 m. (14ft. 9⅛in.), that between conductors and earth at 2·50 m. (8ft. 2⅜in.), and between the protecting gate and the nearest conductor at 3 m. (9ft. 10⅛in.).

Voltage Transformers.—Monophase transformers are connected with the H.T. bus-bars and a potential reducer is inserted at each outgoing line between phase and earth. These reducers consist of a series of ohmic resistances in cascade. The resistances are contained in an oil-filled cylinder of bakelite, which is protected over its whole length by superimposed porcelain ring insulators.

The transformers and switches contain 900 tons of oil. For dehydrating such a large quantity a powerful plant has been installed in which a centrifugal pump draws the oil from the storage tank and conveys it under pressure through an electric heating apparatus and a large filter into the pipe lines which are connected with each transformer and switch. The oil is returned by a second pipe line into the tank or pump inclosed circuit.

Amongst the many protecting devices and relays should be mentioned that of Buchholz, and the Trueb-Taeuber temperature control; an acoustic-luminous alarm installation indicates by differently coloured lamps and by the sounding of hooters or the ringing of bells any irregularity in one of the groups.

Transformer Plant for Railway Traction, 4000/65,000 Volt, 16⅔ Cycles.

The scheme of the low-tension connections is identical with the one described above, with the difference that the connections between alternator and transformer are lead-covered monophase cables—see Fig. 14, p. 358. For each phase two cables in parallel of 350 square millimetres section are used. The H.T. bus-bars have an oil section switch between 6 and 7 and a second switch between 7 and 8. The two lines are branched off the groups 6 and 8. This arrangement makes it possible to insert one or more groups on one or both lines or divide them quickly in case of damage and to supply the railway service from the undamaged line.

The transformers have the following characteristics:

Capacity	8700 kVA
Primary voltage	4000 volts
Secondary voltage	70,925–65,115–61,105
Height	6·47 m. (21ft. 2⅜in.)
Length	4·50 m. (14ft. 9⅛in.)
Width	2·65 m. (8ft. 8⅜in.)
Total weight	64 tons
Weight of core	42 tons
Weight of oil	12½ tons

The transformers are of the three-core type with intersected stampings. The windings are concentric, the primary helical with six sections in parallel and delta connected, the secondary double wound and star connected. The oil-immersed switches, 400 A., are of the multiple six-break type of the following dimensions:—

Diameter of case	1·200 m. (3ft. 11⅛in.)
Height of case	2·000 m. (6ft. 6⅜in.)
Total height of switch	3·150 m. (10ft. 4in.)
Distance between the poles of the three phases	1·500 m. (4ft. 11in.)
Distance between terminals	1·300 m. (4ft. 3⅛in.)
Rupturing capacity	800,000 kVA

Each line is protected by the Bendmann system of automatic arc breaking.

Station Services.—The current required for the internal services is produced by two special groups of generators as mentioned before. The internal services can further be connected with the transformer cabin, 21,000/500 volts, which is fed by the Val Gardena power plant. In the event of a breakdown of the generators the entire circuit is automatically switched over to the transformer cabin.

The switch room of large dimensions is situated on the second floor of the central part of the building. Contrary to the usual practice, this room has large windows with transparent glass panes, as it has been found that top-lighted rooms without any outlook have in the long run a depressing influence upon the attendants. The centre panel comprises the integrating meters, those of the outgoing lines and of the internal services. The panel on the left contains all 42–50 cycles groups, that on the right the 16⅔ cycles groups, and the 10/21,000-volt transformer. The excitation resistances are installed below the switch room in a special room where all the incoming cables are also distributed. In all about 16 miles of lead-covered cables have been laid.

With the exception of a few small special pieces of apparatus, whose cost was below 1 per cent. of the total, the whole machinery has been made in Italy by the following firms:—Sluice gates and control apparatus, Soc. An. A. Calzoni, Bologna; 45,000 h.p. Francis turbines, Soc. An. Construzioni Meccaniche A. Riva, Milan; 15,000 h.p. Pelton turbines, Depretto Escher Wyss, Schio and Franco Tosi, Legnano; 36,000-kVA alternators and transformers, Tecnomasio Italiano Brown Boveri, Milan, and Compagnia Generale di Elettricità, Milan; 9000-kVA alternators, Compagnia Generale di Elettricità, Milan; 9000-kVA transformers, Soc. An. Ercole Marelli and Co., Milan.

We are indebted to the Società Idroelettrica dell' Isarco, the owners of the plant, for the accompanying illustrations.

The Development of Parsons Industrial Turbo Machinery.

No. XIII.

(*Continued from page 323, March 29th.*)

Turbo-blower with Constant Volume Regulator.

When a blast-furnace is kept uniformly charged it is obvious that the weight of air required by the furnace per minute will be constant. But since the resistance of the charge will change from time to time, the pressure necessary to force this constant weight of air through the furnace will change likewise. If, therefore, a uniform quality of iron and a maximum output are to be obtained from the furnace, it is necessary that the blower shall be able to supply automatically a constant weight of air when working

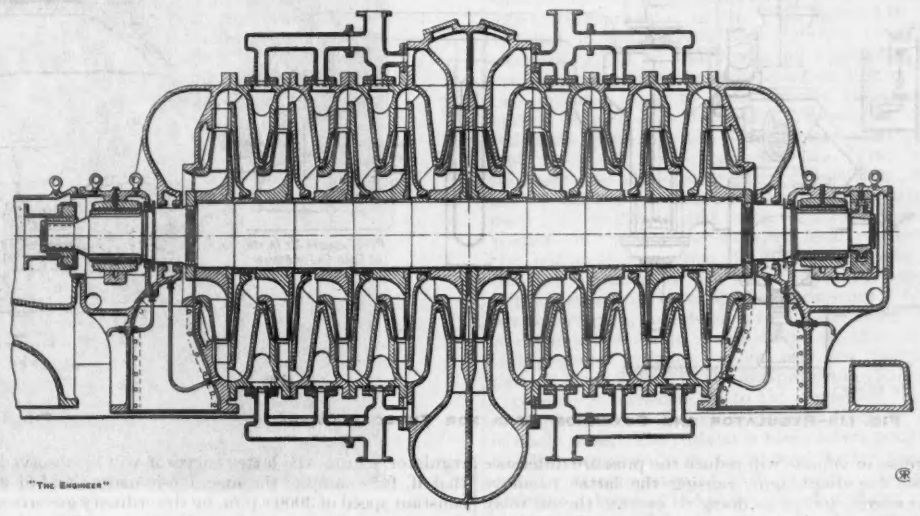


Fig. 117—Double-Ended Turbo-Blower—1926

against different pressures. To fulfil this condition the speed of the blower must be varied in such a way as to maintain constant the volume of the free air drawn in, independently of the pressure of delivery.

The first turbo-blower to be constructed at the Heaton Works with an automatic constant-volume regulating device was a machine ordered in 1926 by the Indian Iron and Steel Company, Ltd., of Calcutta. It was the third turbo-blower to be built by Messrs. Parsons for this company, and was designed for an output of 60,000 to 48,000 cubic feet of free air per minute at a pressure of 23 lb. to 30 lb. per square inch. The earlier sets were smaller machines, the delivery of each being 40,000 to 36,000 cubic feet at 14 lb. to 23·5 lb. pressure. The turbine driving the blower under consideration needs no description, as it is a standard pure reaction machine with a normal speed of about 3000 r.p.m. The blower is of the double-ended centrifugal type, taking in air at each end and discharging it by a central outlet, as shown in the sectional drawing reproduced in Fig. 117. The rotor carries ten impellers altogether, arranged in two groups each consisting of five impellers working in series. All the impellers have a maximum diameter of 48in., so that their peripheral velocity is 630ft. per second when the blower is running at a speed of 3000 r.p.m. The appearance of the rotor, complete with impellers, is shown in Fig. 118, and that of the finished machine with the two older sets in the background is illustrated in Fig. 120.

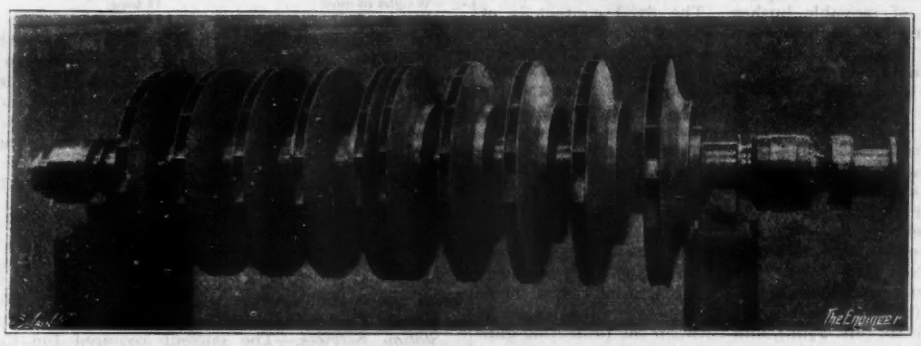


FIG. 118—ROTOR OF DOUBLE-ENDED TURBO-BLOWER

The duty of the constant-volume regulator consists, as indicated above, in adjusting the speed of the blower so as to vary the air pressure in accordance with the resistance to be overcome in the furnace. It does this by acting on the ordinary speed governor of the turbine. A diagrammatic drawing of the regulator and governor gear is given in Fig. 119. The essential part of the regulator is a flexible diaphragm contained in a closed chamber. A pressure difference is maintained across this diaphragm by connecting the spaces above and below it to Pitot tubes placed in the air inlets to the blower. This pressure difference will depend on the velocity of the air entering the blower, and therefore upon the quantity being delivered to the furnace, so that any variation in this volume will bring about a corresponding alteration in the differential pressure across the diaphragm. The equilibrium of the diaphragm is normally maintained by the tension of a spring fitted to the underside of the diaphragm, the tension being adjustable by means of a hand wheel.

The action of the regulator is as follows :—The hand wheel is first set so that the desired volume, as measured by a U tube connected across the Pitot tubes, is being delivered. Should the resistance of the furnace increase, the delivery pressure will tend to rise and the volume of the air to diminish. This decrease in volume will reduce the pressure difference across the diaphragm, causing the latter to move downwards, and in so doing to operate the oil relay controlling the main throttle valve of the turbine. The machine is thus speeded up until the pressure across the diaphragm, and consequently the volume of the air being delivered, is restored substantially to its desired value. Conversely, should the volume tend to rise above the normal, owing to a decrease in the resistance of the furnace, the speed of the turbine will be reduced until the desired quantity is again being delivered. The volume of the air delivered will thus be maintained by the regulator within 2 or 3 per cent. of absolute constancy under any ordinary range of operating conditions. How perfect the control is will be seen by inspection of Fig. 122, which shows in a graphic form the results of tests made on the turbo-blower of the Indian Iron and Steel Company, with and without the automatic volume regulator in action. The three almost vertical lines show the constancy of volume obtained with pressures ranging from about 5 lb. to 30 lb., while the dotted curves show the characteristics of the machine without the regulator. From the latter curves it will be observed that if, for example, the machine is maintained at a constant speed of 3000 r.p.m. by the ordinary governor the volume will increase from 40,000 to 60,000 cubic feet per minute for a drop in pressure from 22·5 lb. to 14·5 lb., whereas with the regulator in action the increase in volume for the same pressure variation would be negligible.

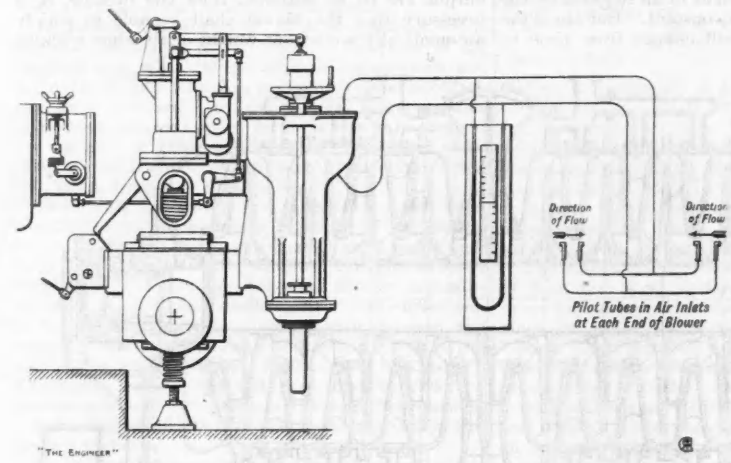


FIG. 119—REGULATOR AND GOVERNOR GEAR FOR TURBO-BLOWER

The levers and attachments to the governor gear are so arranged that, should the constant-volume regulator fail for any cause, such as a broken pipe or connection or what not, the turbine will be still controlled by the speed governor in the ordinary way. The speeding up of the machine due to the fall of the diaphragm is therefore limited to the speed for which the ordinary governor has been set.

A fourth turbo-blower similar to the above machine was ordered in 1928. Tests on this machine were carried out by W. Bolton Shaw, consulting engineer to the Indian Iron and Steel Company, Ltd., and his results are given in Table IV.

Pass-out Turbines with Rotary Valve Gear.

It will be recalled that the first "pass-out" turbine constructed at the Heaton Works was a machine supplied to the Edinburgh Roperies in 1911. This turbine was provided with a separate external steam chest containing the pass-out valve, a practice which was adhered to in all the machines of the pass-out type built prior to the year 1926. At that time a definite change in design was adopted, the previous double-beat pass-out valve being replaced by a rotary valve which was incorporated in the turbine itself. The alteration avoided the losses involved in the pipework necessary with the earlier arrangement, and at the same time considerably improved the appearance of the machine.

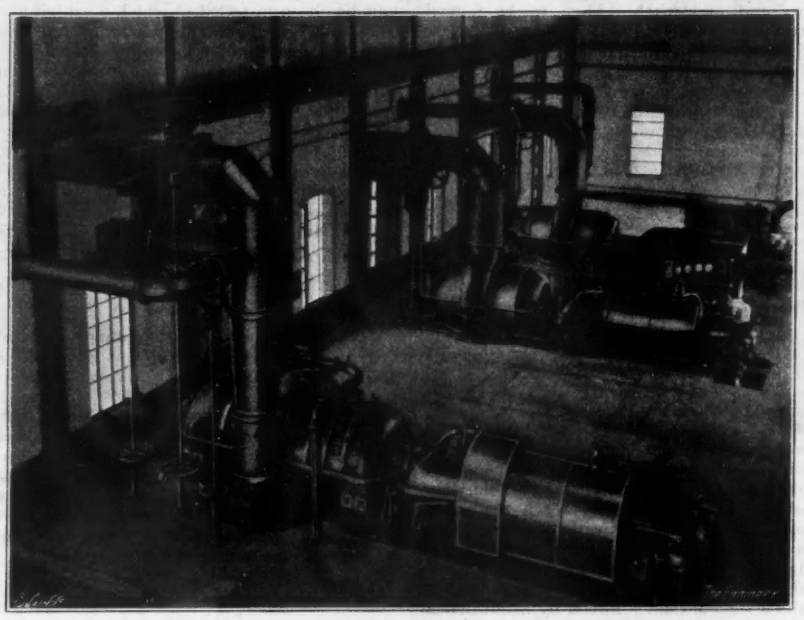


FIG. 120—TURBO-BLOWERS FOR INDIAN IRON AND STEEL COMPANY

The new valve gear was first used in a 2300-kW pass-out turbine ordered in 1926 by the Australian Paper and Pulp Company, Ltd., and almost simultaneously in a much larger machine, rated at 5000 kW, built for the Northfleet Paper Mills in Kent. Both turbines were of the pure reaction type, the former working with steam at 340 lb. pressure, superheated to 700 deg. Fah., and passing out steam at a gauge pressure of 135 lb., the latter taking steam at 300 lb. and 672 deg. Fah. passing out at 35 lb. gauge.

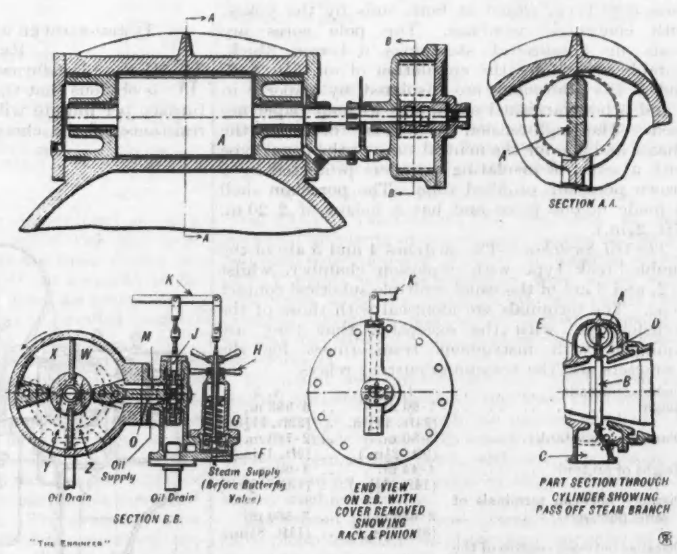

SECTION A.A.
SECTION B.B.
Oil Supply
Oil Drain
Oil Drain
Steam Supply (Before Butterfly Valve)
END VIEW ON B.B. WITH COVER REMOVED SHOWING RACK & PINION
PART SECTION THROUGH CYLINDER SHOWING PASS OFF STEAM BRANCH
"THE ENGINEER"

FIG. 121—PASS-OUT VALVE GEAR—1926

An illustration of the Australian turbine is given in Fig. 123, and a section through the 5000-kW machine for the Northfleet Paper Mills in Fig. 125. From this drawing it will be seen that, as in previous pass-out turbines, the cylinder is divided internally into two parts by a diaphragm at the pass-out point. In the present design, however, the portion of the steam which is to complete its expansion in the blading on the downstream side of the diaphragm does not leave the turbine, but is allowed to pass through the diaphragm by means of the rotary valve shown.

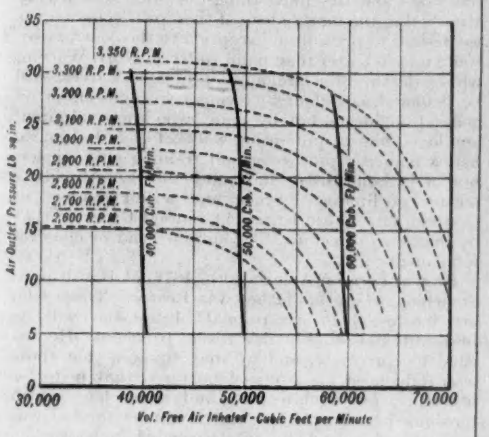


FIG. 122—CHARACTERISTIC CURVES OF TURBO-BLOWER

The method by which the pressure of the pass-out steam is maintained constant will be understood from the details of the valve gear shown in Fig. 121. The steam is taken from the belt E on the upstream side of the diaphragm, and leaves the turbine by the branch C. The surplus steam, in excess of that required for heating, passes through the rotary valve A, and continues its expansion in the low-pressure portion of the turbine. The valve A is operated by a rotary oil relay on the end of the valve spindle, the action of this relay being controlled by the pressure of the pass-out steam in the belt E. Oil is supplied under pressure by the main relay pump to the central part of the relay chest, and its admission to the relay cylinder is controlled by the plunger J. The valve A maintains a practically constant pressure in the pass-out belt in the following manner. If there is a decrease in the demand for heating steam, the pressure in the pass-out belt will tend to rise. This will raise the piston F against the action of the spring G, and will consequently lift the plunger J. Oil will then pass to chambers W and Y of the relay, and chambers X and Z will be connected to the drain.

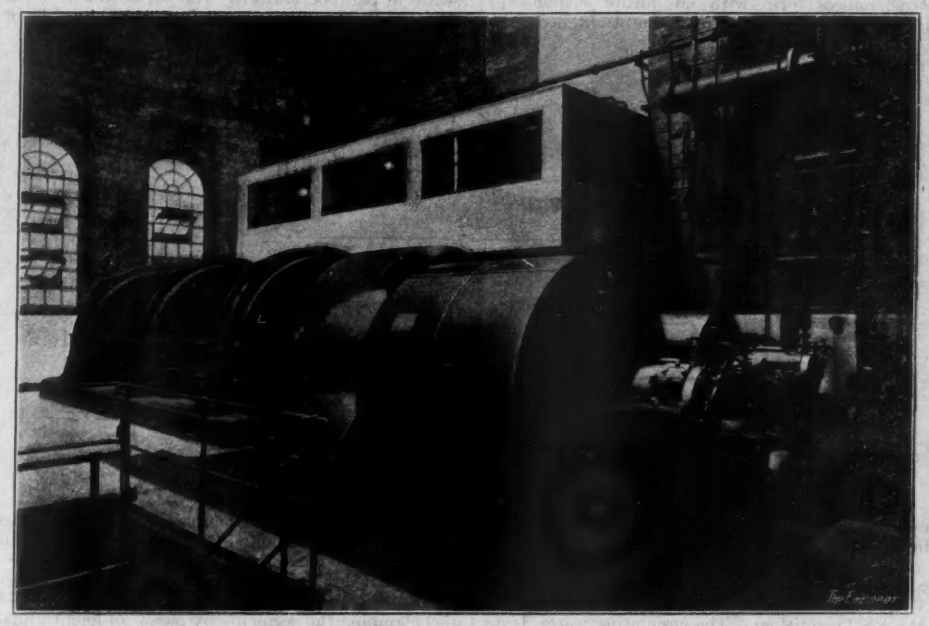


FIG. 124—6000-KW SIDE-BY-SIDE GEARED TURBO-GENERATOR—1927

The blades will therefore revolve in the direction of the arrow, thus opening the valve until the plunger is restored to its neutral position by the lever K and the rack which is geared to the end of the valve spindle.

The extra steam thus passed through the diaphragm to the low-pressure part of the turbine tends to cause a slight increase in the speed of the machine, but this increase is automatically checked by the action of the main governor which reduces the opening of the main throttle valve. If the demand for heating steam increases, the pressure in the pass-out belt will begin to fall, and the controlling piston F will be forced down by the spring G. This action will lower the relay plunger, admitting oil to the chambers Z and X, and allowing it to escape from the chambers W and Y, thus reducing the opening of the rotary valve. Owing to the decreased quantity of steam then able to flow through the low-pressure blading, the speed of the turbine will tend to decrease, thus bringing into action the main governor, which will at once open the throttle valve by the required amount.

The actual value of the pass-out pressure can be regulated within reasonable limits by adjusting the tension of the controlling spring G by means of the hand wheel H.

Until the turbine is actually running, there is, of course, no oil pressure to operate the relay, so that before starting the pass-out valve must be opened by hand. This is done by means of a lever provided for the purpose, which turns the valve spindle. The valve is held slightly open by a cam. As the speed of the turbine approaches the normal, the pass-out pressure will rise and cause the valve to be opened further. This will release the cam, which will fall out of position automatically and leave the valve under the control of the relay.

TABLE IV.—*Tests of Turbo-Blower for India.*

Date of test	14.3.29	14.3.29	15.3.29
Air inlet temperature, deg. Fah.	61·3	60·5	58·5
Air outlet temperature, deg. Fah.	242·3	237·6	261·5
Rise in air temperature, deg. Fah.	182·0	177·1	203·1
Barometer	30·37	30·37	30·38
Air outlet pressure, lb. per square inch gauge	22·97	23·01	28·18
Pressure in measuring drum, inch Hg.	5·84	4·87	3·89
Air temperature at measuring orifice, deg. Fah.	234	227·5	244
Diameter of measuring orifice, inches	20	20	20
Effective area of measuring orifice, square feet (coefficient of discharge = 0·99)	2·16	2·16	2·16
Cooling water, quantity, lb. per minute	4,500	4,375	4,500
Cooling water inlet temperature, deg. Fah.	71·35	70·77	59·5
Cooling water outlet temperature, deg. Fah.	77·85	77·08	67·57
Rise in water temperature, deg. Fah.	6·5	6·31	8·07
Speed, r.p.m.	3,340	3,200	3,280
Volume of air at orifice, cubic feet per minute	73,000	68,400	63,800
Volume of air at inlet, cubic feet per minute	65,500	60,100	53,000
Adiabatic temperature rise, deg. Fah.	161·5	162·2	187
Specific volume at inlet, cubic feet per lb.	12·97	12·95	12·9
Specific volume of air in drum	14·47	14·71	15·5
Adiabatic A.H.P.	4,565	4,220	4,300
Thermal power in air	5,150	4,600	4,670
Thermal power in water	690	651	856
Bearing losses, B.H.P.	108	103	106
Total B.H.P., including all losses	5,948	5,354	5,632
Blower efficiency, per cent. $\frac{\text{A.H.P.}}{\text{B.H.P.}} \times 100$	76·8	78·8	76·4

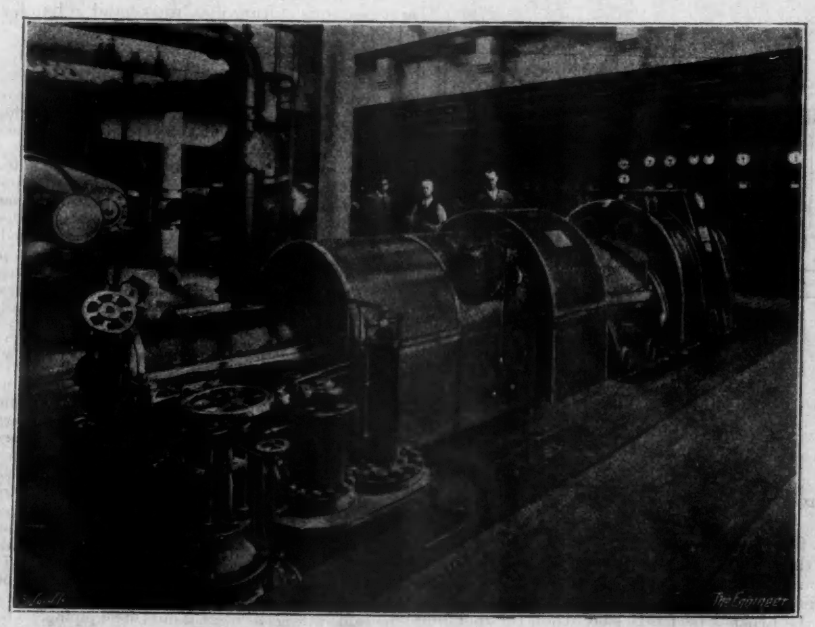


FIG. 123—2300-KW PASS-OUT TURBINE FOR AUSTRALIA—1926

SIDE-BY-SIDE GEARED TURBINE AND CONTINUOUS CURRENT GENERATORS.

Between the years 1918 and 1927 seven continuous-current turbo-generating units, with an aggregate capacity of no less than 36,000 kW, were installed in the private power station of a large chemical works in the North of England. Each machine consisted of a pure reaction turbine with two cylinders side by side, driving three direct-current dynamos in tandem by means of speed-reduction gearing. The arrangement of the sets will be clear from Figs. 124 and 126, which illustrate one of the latest pairs of machines. These are of identical design, each having a capacity of 6000 kW at 230 to 260 volts. The high-pressure portion of the turbine runs at 6000 revolutions, the low-pressure portion at 3600 revolutions, and the three dynamos at 375 r.p.m. Steam is supplied to the turbine stop valve at a gauge pressure of 550 lb. per square inch, superheated to 750 deg. Fah. This is expanded down to about 52 lb. absolute in the high pressure cylinder, which contains thirty-two pairs of blade rows. In the low-pressure cylinder the expansion is carried down to the condenser vacuum of 28·8in., this cylinder containing eighteen pairs of blade rows. The turbine is bled at two points for feed heating, steam being taken from the low-pressure cylinder at a pressure of 15 lb. absolute, and again from the exhaust of the high-pressure cylinder where the pressure is 52 lb. absolute. By this means the

condensate is reheated regeneratively to a temperature of 250 deg. Fah.

Both turbine rotors are machined from solid forgings, and the heights of the successive blade rows increase continuously so as to give a steam passage of true conical form with no abrupt changes in diameter. The blading is of the end-tightened type throughout, except five rows of the low-pressure cylinder. A runaway governor is fitted to the end of each of the two turbine shafts, both governors acting on a single emergency valve.

The surface condenser is of a special design, owing to the local conditions. The circulating water, being of an acid nature, affects the tubes, and means had to be provided to enable the plant to be kept running with one half of the condenser out of action for the replacement of the tubes. To meet this requirement the condenser is built practically in the form of two separate condensers in a single shell, each having its own separate steam inlet controlled by a valve. Half of the total condensing surface can thus be put out of action, the turbine running on the other half for the time being.

The electrical portion of the unit comprises three dynamos, each with a maximum continuous rating of 2000 kW. These dynamos are connected electrically in parallel, and give thus an output of from 23,100 to 25,000 ampères at 260 to 230 volts. They are shunt wound, with laminated main poles and mild steel interpoles bolted to the yokes. Because of the very heavy currents to be dealt with each generator has a double commutator. The commutators are of the V-ring construction, end rings of mild steel clamping the segments by means of longitudinal bolts. The hub is of cast iron with the end rings keyed to it. A feature that will be remarked is the accessibility of the brush gear, which is carried on a separate yoke encircling the centre of each commutator. This arrangement renders the examination and adjustment of the brushes perfectly easy when the machine is running.

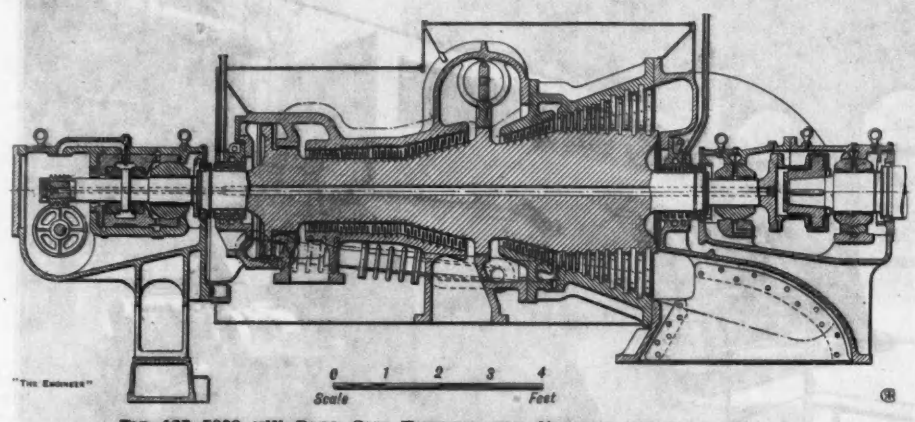
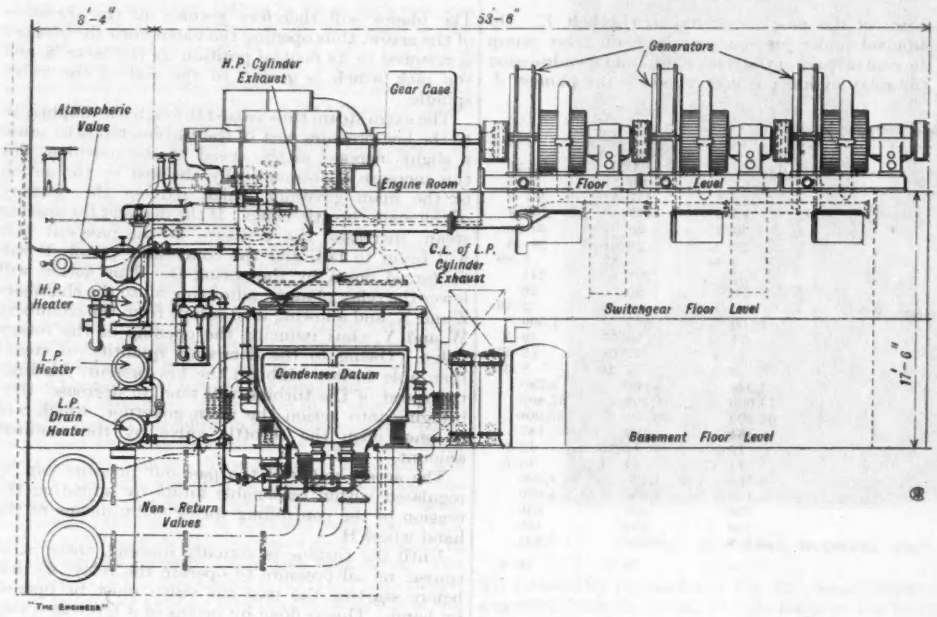


Fig. 125—5000-kW Pass-Out Turbine for Northfleet Paper Mills



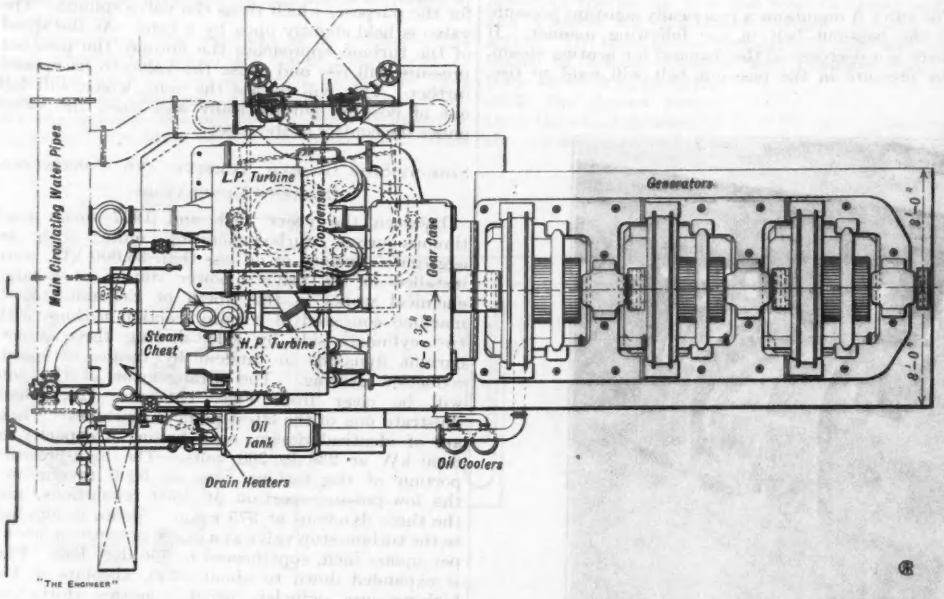


Fig. 126—6000-kW Side-by-Side Geared Turbo-Generator

(*To be continued.*)

Obituary.

J. G. H. WARREN.

It is commonly believed, and not quite unjustifiably, that engineers are men of single interests, lacking the taste for the finer things of life, and wholly absorbed in the materialism of their own vocation. If we desired to present an exception to the contrary we could not do better than point to Mr. J. G. H. Warren, whose death, after prolonged illness, last week, will be deplored, not alone by locomotive engineers or by general engineers, but by many who knew, admired, and loved him in quite other walks of life. In him we had a man, by profession and training an engineer, but of catholic tastes and wide culture. Already a master of literary French, and a fair student of German, late in life he taught himself Greek so that he might go direct to the fountain head of classical refinement.

He was born on August 30th, 1876, at Bawdrip, in Somerset, where his father was Rector. Those who are interested in exceptional phenomena will be pleased to note that he never went to school. He was educated privately, and we may suppose that those who influenced his boyhood nurtured that taste for literature, art, architecture, and archæology which blossomed later. At the age of sixteen the lad was sent to Neilson and Co., of Glasgow, where he worked all day and continued his education in the evenings and his spare time. He developed at Neilsons, at Kerr Stuarts, and later at Bagnalls such skill as a locomotive draughtsman and designer that the late Mr. J. M. Galt invited him to go as chief of the drawing-office to Robert Stephenson and Co., Ltd., at Darlington, and there he remained from the middle of 1904 till 1923, when trouble with his eyes, and indifferent health made it necessary for him to retire. He spent the rest of his days at Bath. But his was not a life of inactive retirement. He was a director and later chairman of the Wrightlington Colliery Company and vice-chairman of the Chancery-lane Safe Deposits and Office Company. His interest in the colliery was intimate and practical. He applied in that work his wide knowledge of engineering and introduced material improvements of various kinds.

There is no lover of locomotives and locomotive history who is not familiar with Warren's principal literary work. In June, 1923, Stephensons celebrated their centenary. For two years before that date his whole time was devoted to the book which bears his name, "A Century of Locomotive Building," published by Andrew Reid and Co., Ltd., for the firm. That book possesses literary qualities above the ordinary and is so thorough and so complete that in the decade and more which has passed since it appeared very little emendation or addition has been found necessary. It is a monument by which his name will always be remembered.

We have tried to give the reader who had not the pleasure of Warren's friendship some idea of his avocations—that is, interests outside his usual calling or vocation. We may add to those we have mentioned that he became after his retirement a student of music, heraldry, wood engraving, and book plates, and that he was a keen gardener and an observer of wild birds. His love of architecture was such that he was one of the original supporters of the Bath Preservation Society and lectured for it. He was also a member of the Somerset Archæological Society, the Bath Literary Society, and a trustee of the Holburne of Menstrie Museum of Art in Bath. When we recall that all these activities were pursued in the face of persistent bad health we wonder at the courage of the man at the same time that we admire and thank him for showing the world that engineering and generous culture may walk hand in hand.

In order to protect sand beds for drying sewage sludge from the vagaries of the weather, and thus permit their reduction in area, beds covered with glass after the fashion of a greenhouse have been tried in America. The scheme has allowed beds to be built on the basis of ¼ square foot per capita, but this halving of the size did not halve the cost, as the extra cost of the covered bed more than made up the difference. However, by retaining the sludge under cover it was found that the beds could be placed closer to built-up districts, and the people did not seem to object to them, perhaps, says Mr. E. B. Besselievre, of the Door Company, for the reason that a greenhouse being associated with flowers and pleasant smells made them forget that sewage had any odour.

A laminated resin product known as Keebush has recently been developed in England, with special regard to the chemical engineering aspects of the material. Tests on a laminated 1in. bolt gave a breaking load of 6·7 tons per square inch. A hydraulic test carried out on a Keebush pipe, internal diameter 2in., external diameter 2·43in., length 40½in., and fitted with six flanges, was described by Mr. M. B. Donald to the Chemical Engineering Group. At 225 lb. per square inch there was a slight seepage through the flange threads at both ends. At 1300 lb. per square inch a number of pin holes opened along the whole length of the pipe, and the pressure could not be increased to more than 1600 lb. per square inch. The pipes are normally supplied for a working pressure of 50 lb. per square inch, and to the same standard dimensions and with the same fittings as normal mild steel piping. The flanges can be joined by using bolts and nuts of the same material, which also conform to British standards.

The Twenty-four-Foot Wind Tunnel at Farnborough.

No. I.

ACCORDING to the theory of dynamical similarity, the results of any test involving the exposure of a model structure to the reaction of a fluid in motion relatively to it will be directly applicable to a geometrically similar structure of enlarged scale if the Reynolds number for the model test conditions is equal to the Reynolds number for the enlarged scale conditions. This principle, first expounded by Newton and developed within recent times by the late Lord Rayleigh and others, enters into the testing of ship models in tanks. In aeronautical work, largely because of the much higher velocities involved, it not only enters into, but may truly be said to dominate, research based on the use of models.

The quantity known as the Reynolds number is expressed by $R = l V \rho/\mu$, where l is any suitable linear dimension of the model or enlarged scale structure, V is the velocity of the fluid relatively to it, and ρ and μ are respectively the density and the coefficient of viscosity of the fluid.

To illustrate the significance of this quantity in aeronautical research let us consider the problem of

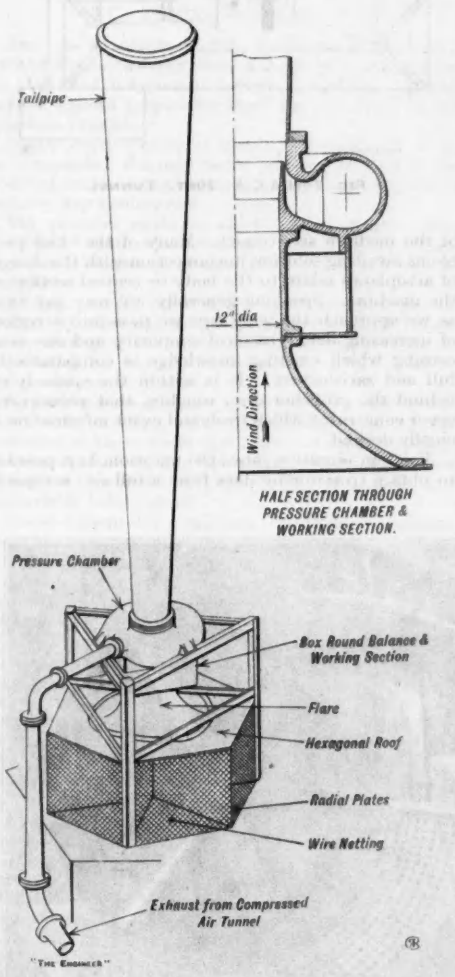


FIG. 1—N.P.L. 12 IN. HIGH-SPEED TUNNEL

determining by model test the forces in action on an aeroplane of 35ft. span, when flying at 200 m.p.h. The model, it is to be supposed, reproduces in all respects the details of the full-scale machine. We will take it that the wind tunnel available restricts us to the use of a model of 5ft. span. Then according to the theory of dynamical similarity the data obtained from the model tests will be directly applicable to the full-size machine if the one-seventh scale of the model is compensated by a seven-fold increase in the joint effect of the other factors composing the Reynolds number. If the one-seventh reduction in the factor l is not so compensated then the model test results will not be applicable to the full-size machine until they have been corrected for "scale effect." In general the scale effect correction has to be determined experimentally by means of tests on models of increasing size.

Let us consider the practical implications of the requirement that the joint effect of the factors V, ρ and μ is to be increased seven-fold to compensate for the reduction of the factor l to one-seventh of the full-size value.

Little opportunity for adjustment is presented by departing from air as the fluid for the model tests, and using instead some other gas or a liquid of lower viscosity and higher density. Water would certainly give an increase in the density factor and also an increase in the joint effect of the density and viscosity factors. The use of water is however not practical because of the amount of power which would be required to maintain the fluid in motion and because of the stoutness and consequent high interference characteristics of the supports necessary to sustain the model. The best that could be done by a resort to change of fluid would appear to be afforded by the adoption of carbon dioxide instead of air. Against the use of this gas there are several serious practical objections. It may therefore be taken that air is the only practicable fluid which may be used.

No real opportunity for effecting the required adjustment being presented by a change of fluid let us consider next the velocity factor. To compensate for the one-seventh scale of the model purely by adjusting the velocity we would have to test the model in a current of seven-fold speed or at 1400 m.p.h. This speed is far beyond what can be realised in any wind tunnel. It is in fact just about twice the velocity of sound in air.

The velocity of sound in air, roughly 700 m.p.h., establishes a theoretical limit to the wind tunnel speed which may be employed. The reaction of a current of air flowing at or near the velocity of sound is affected by compressibility and other factors which are absent or negligible at lower speeds. The data derived from a model exposed to such a flow would, therefore, be inapplicable to a full-size machine subjected to the forces of a wind-flow of relatively low velocity.

Taking then 700 m.p.h. as the theoretical limit for the velocity which may be attained in a wind tunnel we see that, in the example being considered, we cannot hope to effect more than half the adjustment required by operating on the velocity factor alone. With the wind current limited to 700 m.p.h. the results obtained from our one-seventh scale model would be directly applicable to the full-size machine when flying, not at 200 m.p.h., but at half that speed.

The highest wind tunnel speed of which we have a record approaches very nearly the velocity of sound in air. In the course of some experiments at the National Physical Laboratory, Messrs. Bailey and Wood produced an air current flowing at about 670 m.p.h. The "tunnel" in which this velocity was developed was, however, only 2¼in. in diameter. Based on these experiments a high-speed wind tunnel (Fig. 1) has recently been constructed at Teddington. This tunnel has a diameter of 12in. and in it wind velocities up to 665 m.p.h. can be reached.* Ascending the scale of diameter we descend the scale of speed. At Wright Field, the technical centre of the U.S. Army Air Corps, there is a so-called "full-speed" tunnel, 5ft. in diameter in which a wind speed of 275 m.p.h. is attained. As an example of a less abnormal tunnel mention may be made of one—one of two similar tunnels—recently completed at the National Physical Laboratory. This tunnel (Fig. 2) has an elliptical section measur-

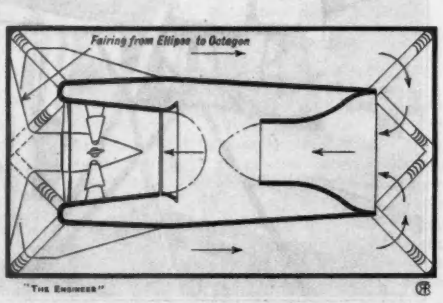


FIG. 2—N.P.L. 7 FT. BY 9 FT. OPEN-JET TUNNEL

ing 7ft. by 9ft. 1½in. and in it wind speeds up to about 140 m.p.h. are reached. In France the Issy tunnel has a diameter of 10ft. and a wind speed of about 190 m.p.h.

If we place the maximum velocity obtainable in a tunnel capable of accommodating a model of 5ft. span at 300 m.p.h. we shall probably exaggerate what is within the range of present practice. Taking that figure, however, as the practical limit, we see that the greatest possible adjustment which can be made in the velocity factor is, by itself, quite insufficient to compensate for the reduced scale of our model. At a wind speed of 300 m.p.h. the test results obtained would be directly applicable to the full-size machine flying, not at 200 m.p.h., but at only 60 m.p.h., or somewhere in the neighbourhood of the stalling speed.

* The accompanying illustration of the 12in. high-speed tunnel is from a drawing which we are enabled to reproduce by courtesy of the National Physical Laboratory.

It is to be noted that the dimensions of existing tunnels given above are those of the actual walls of the structures. The working areas of the wind currents are in all cases of less dimensions because the outer layers of the air jets are not of sufficiently uniform velocity to permit them to be used. It is also to be noted that a wing span of 35ft. corresponds with that of a single-seater fighter or a light aeroplane and that machines with spans up to 130ft. and even more are now being built. It is evident therefore that to study certain designs of machines by means of wind tunnel research it may be necessary to use models of one-tenth, or even one-twentieth scale. As a result the position with respect to the velocity is aggravated.

The remaining factor open to adjustment is the density of the air composing the current. Working on this factor alone we can compensate for the one-seventh scale of our model by circulating through the wind tunnel air at seven times the atmospheric pressure. With air at this pressure it would still be necessary in order to fulfil the conditions of dynamical similarity to make the air flow at the full-scale speed of 200 m.p.h. The energy stored in the circulating air—and very approximately the energy which must be expended in maintaining it in circulation—is proportional to the pressure and to the square of the velocity. Hence it may prove economical of power to increase the pressure more than is required to compensate for the scale of the model and to use the surplus for the reduction of the velocity below the full-size value. For example if we used air at 14 atmo-

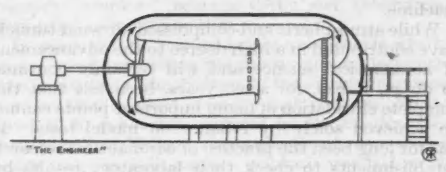


FIG. 3—N.A.C.A. VARIABLE DENSITY TUNNEL

spheres pressure with our one-seventh scale model the conditions of dynamical similarity would be satisfied if the wind speed were reduced to 100 m.p.h.

At Langley Field, Virginia, the American National Advisory Committee for Aeronautics has a compressed air tunnel (Fig. 3) in which a stream of air 5ft. in diameter and at a pressure up to 20 atmospheres can be circulated at a speed of 48 m.p.h. A later design of compressed air tunnel exists at the National Physical Laboratory. This tunnel (Fig. 4) was described and illustrated in our issues of March 17th and 24th, 1933. It has a jet 6ft. in diameter through which air at 25 atmospheres pressure is circulated at 61 m.p.h. In the N.P.L. tunnel at full pressure a velocity of 56 m.p.h. would be sufficient to fulfil the

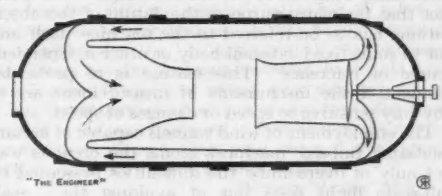


FIG. 4—N.P.L. COMPRESSED AIR TUNNEL

conditions of dynamical similarity in the case of our one-seventh scale model.

From a recent paper read before the Royal Aeronautical Society by Mr. E. F. Relf, Superintendent of the Aerodynamics Department of the N.P.L., it would appear to be established that the compressed air tunnel may be accepted as a sound means of realising the conditions of dynamical similarity in model tests. The Teddington tunnel has already yielded results of very great interest and value. In particular, it is throwing much light upon the precise manner in which aerodynamic forces vary with the Reynolds number, and is thereby helping to increase the certainty with which results obtained under low Reynolds number conditions—as in atmospheric tunnels—may be extrapolated to the full-size conditions.

It cannot, however, be disputed that compressed air tunnels suffer from at least three major disadvantages. In the first place the actual tunnel and model have of necessity to be enclosed within a large air-tight shell capable of withstanding a pressure up to say 350 lb. per square inch. The model during the test is therefore inaccessible and all the forces acting on it have to be measured by means of devices—actually electrical—with leads to the outside. The inaccessibility of the model implies that in order to set it up on the balance the pressure inside the casing must be reduced to atmospheric and that before the test can be begun the pressure must be raised again to the desired value. The time and power expended in this manner are considerable with the result that the operation of the tunnel is slow and costly. In this connection it is of interest to note that the new small high-speed tunnel at the N.P.L. to which reference was made above is operated by the air from the compressed air tunnel when it is being discharged. The energy in the compressed air will therefore be put to a useful purpose although the arrangement may be found considerably to delay the rapidity

with which the compressed air tunnel can be re-set for a fresh experiment.

Secondly it is evident that even a six-foot tunnel with air at 25 atmospheres and a speed of 61 m.p.h. does not permit other than small or very slow machines to be tested by model at full-scale Reynolds numbers. For example, a machine of 75ft. span would involve the use of a model not larger than one-fifteenth scale in order that it might be accommodated within the working area of the jet. At the full pressure and the full velocity the wind tunnel results on such a model would be applicable to the full-size machine flying at 102 m.p.h.

Thirdly, and perhaps most importantly from the purely aerodynamic point of view, the wind tunnel results will be applicable to the full-size machine if, in addition to the Reynolds numbers being the same, the model is an exact reproduction of the machine. The smaller the model the more difficult is it to ensure exactness of reproduction and it appears to be established that the greater the density of the air current to which it is exposed the greater will be the effect on the results of any departure from exactness in reproduction. There is little doubt that at full Reynolds numbers the omission of some minor detail such as the aileron operating levers or the pitot static head may affect the drag measurements obtained from the model. In addition, the difficult question of relative surface roughness is involved. It is certain that at full or high Reynolds numbers a varnished wooden model cannot be regarded as a wholly satisfactory representation of a fabric-covered machine.

While atmospheric and compressed air wind tunnels have contributed in a high degree to the advancement of aeronautical science and will certainly continue to do so, it has, for some years, been felt that the complete elucidation of many important points cannot be achieved solely by reliance on model tests. It has for long been the practice of aeronautical research establishments to check their laboratory results by means of observations made on actual machines when in the air. There are, however, as will be readily understood, severe limitations on full-scale work of this nature. Apart from difficulties presented in obtaining uniform conditions and in the accurate measurement of the quantities being studied the investigation of the forces in action on a machine in flight is complicated by the fact that the forces measured are in general those on the machine as a whole and cannot readily be allocated in correct proportion to the different parts of the machine. For example measurements of the drag of the machine cannot be directly divided between the drag of the wings and the drag of the body. In addition investigations made in actual flight must always be carried out with full regard to the safety of the machine, its pilot and the observer. Perhaps, however, the most hampering feature in full-scale flight tests is the fact that for many purposes the datum of the observations has to be referred to the machine itself and not to some fixed external body or other independent source of reference. This feature is of particular moment if the instruments of measurement are in any way sensitive to speed or changes of speed.

The employment of wind tunnels capable of accommodating full-size machines seems the obvious way not only of overcoming the difficulties presented by full-scale flight tests but of avoiding the "scale effect" aspects associated with model tests. Two

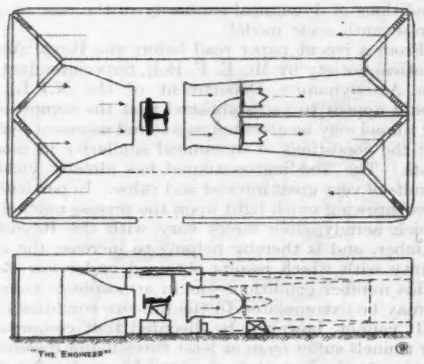


FIG. 5—N.A.C.A. 30FT. BY 60FT. FULL-SCALE TUNNEL

full-scale tunnels which are now in use permit us to examine the validity of this conclusion. In America the National Advisory Council for Aeronautics has recently constructed and brought into use a tunnel (Fig. 5) of oval section measuring 30ft. by 60ft. in which an air jet at atmospheric pressure can be caused to flow at a speed of 118 m.p.h. for an expenditure of 8000 h.p. Still more recently, as described in our issue of December 21st, 1934, the French Aeronautical Department has erected at Chalais-Meudon an elliptical-sectioned tunnel (Fig. 6) of 52ft. 6in. major axis designed for a wind speed of about 112 m.p.h. The horse-power in this case is 6000.

The most conspicuous feature of these two immense tunnels is, from our present point of view, the fact that while their dimensions are sufficient to permit them to accommodate full-size aeroplanes of small or medium span, the wind current velocity provided is only one-half and even less than one-half of the actual flying speeds of many modern aeroplanes. It follows therefore that even in these full-scale tunnels the tests carried out are conducted at Reynolds numbers which are only half or less than half the Reynolds numbers for many machines in actual flight.

It may be asked why the American and French authorities, having gone to full-scale dimensions, have stopped short of full-scale speeds. The answer is to be found in the expenditure of power required to maintain the air jet in motion. That power is out of all proportion greater than the engine power required to maintain the aeroplane tested in free flight. For example a single-seater fighter of 35ft.

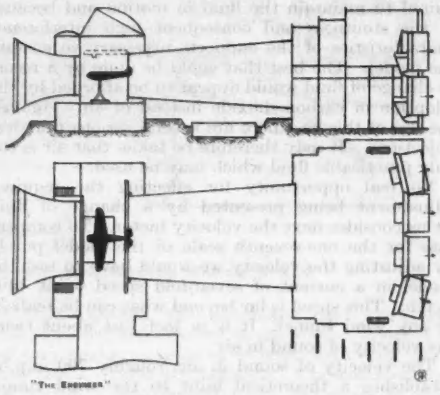


FIG. 6—CHALAIS-MEUDON 52FT. TUNNEL

span and a speed of 200 m.p.h. would be equipped with an engine developing about 600 h.p. Such a machine might be tested at the Chalais-Meudon station at just over half its flying speed. The expenditure of power on the maintenance of the wind current would, however, amount to 6000 h.p. If the velocity were doubled to bring it to equality with the actual flying speed of the machine the horse-power required to maintain the jet would be quadrupled to 24,000. Even although the cost for power might be held to be tolerable some doubt may be expressed as to whether grave and probably insurmountable difficulties of an engineering order would not be encountered in installing the fan equipment required to create and maintain the wind current. At the Chalais-Meudon station acute engineering problems were presented in the design of the end wall of the building in which are disposed six fans each 28ft. in diameter and each coupled to a motor of 1000 h.p. To double the speed of the current and quadruple the driving power would probably present the designers of the building with a problem beyond their capacity to solve in a rational manner.

It will now be seen that both at the low and at the high end of the wind tunnel range difficulties of an aerodynamic or engineering nature present themselves. There remains to examine the middle portion of the range embracing tunnels of medium dimensions capable of holding if not full-size aeroplanes at least full-size components or large scale models. An example of this category is to be found in the 20ft. tunnel (Fig. 7) of the National Advisory Committee for Aeronautics at Langley Field. In this tunnel, for the expenditure of 2000 h.p., an air current, of atmospheric pressure, flowing at 110 m.p.h. can be maintained. Another example is the new 24ft. tunnel, Fig. 8, at the Royal Aircraft Establishment, South Farnborough, Hants, with the design and construction of which we shall presently be concerned. The speed and power of the English tunnel, in spite of the larger diameter, are about the same as those of the American.

Apart from the possibility of using very large models—say one-third or even one-half scale—presented by the medium size tunnel, it possesses the advantage that, without an excessive expenditure of power or at excessive first cost for buildings and equipment, it permits tests to be carried out on full-size components such as complete wings or propellers. Since the scale ratio is 1 to 1 the Reynolds number of the test results on these components will be affected only by the fact that the wind tunnel velocity is less than the actual flying velocity. A more important consideration, however, must be mentioned in any discussion of the relative merits

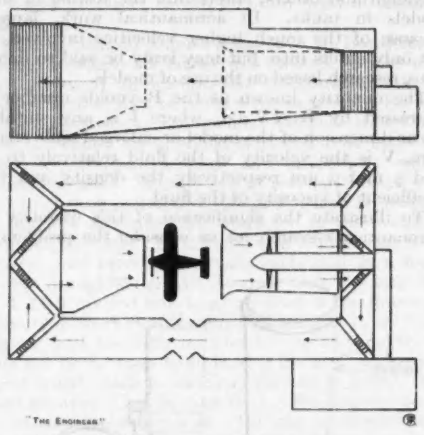


FIG. 7—N.A.C.A. 20FT. TUNNEL

of the medium size tunnel. Many of the chief problems awaiting solution in connection with the design of aeroplanes relate to the body or central section of the machine. Speaking generally, we may say that as we approach the wing tips we pass into a region of increasing aerodynamical simplicity and one concerning which existing knowledge is comparatively full and satisfactory. It is within the space lying behind the propeller disc, roughly, that phenomena occur concerning which fresh and exact information is chiefly desired.

This consideration raises the question, Is it possible to obtain trustworthy data from a full-size aeroplane

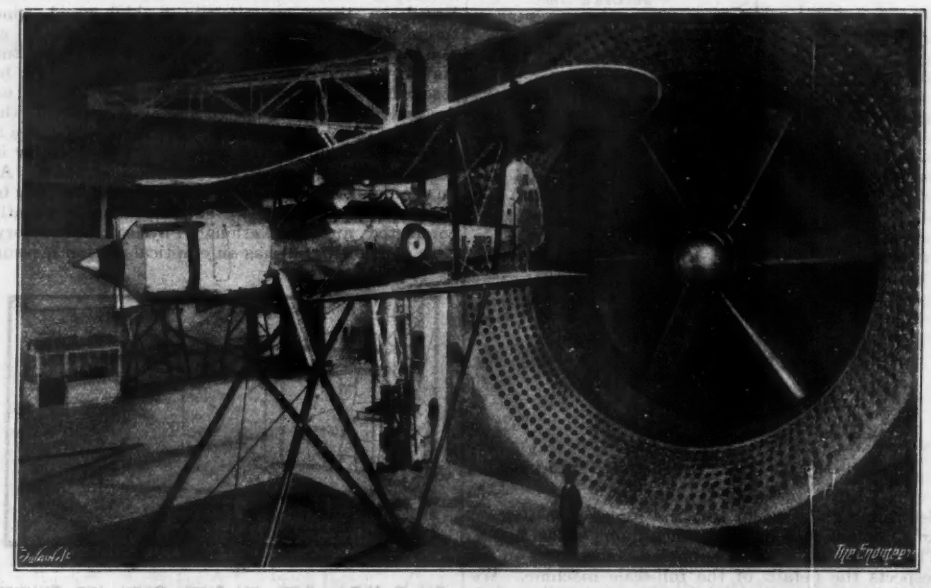


FIG. 8—R.A.E. 24FT. TUNNEL FOR FULL-SCALE AND MODEL TESTS

spanning an air current with its wing tips projecting beyond the air stream? Investigation has shown that this method of working yields satisfactory results so long as the measurements taken relate to the body portions of the machine which lie well within the area of the jet. For some purposes it will doubtlessly be permissible to test the machine with its wings removed. For example the resistance of undercarriages might be measured without the wings in position. For other purposes however the presence of the wings even although they are only partially exposed to the full air current will be necessary to give truth to the measurements. Cases of this kind may be expected to arise in connection with the study of the drag and lift forces acting on the body behind the wings or on the tail planes, elevator and rudder.

Perhaps the most important respect in which the medium-size tunnel will prove of value will be in the

study of many aspects involving the propeller or engine or both. The slip stream from an air screw is known greatly to affect various aerodynamical quantities, such as the drag of the body. In a model test, except by resort to the use of an electrically driven model air screw, it is not possible to examine the actual magnitude of these slip stream effects. In the medium-size tunnel it will be practicable to conduct tests with the air screw running under the power of its own engine. This possibility makes it necessary carefully to consider the ventilation of the air stream in order that a pilot or observer in the cockpit may not be affected by the accumulation of exhaust gases circulating with the stream.

Another important aspect involving the engine which the medium-size tunnel will permit to be investigated is the effect of modifications to the engine cowling. The Townend ring, as is well known, effects a surprisingly great reduction in the drag of a machine to the engine of which it is fitted. Its action in this respect does not stop short at the engine, but extends to some considerable distance down the body. It has however to be recognised that the head resistance of an engine is physically interconnected with its air cooling characteritics, and that any form of cowling must be designed—in the case of an air-cooled engine—with both features in mind. Much attention has recently been given to this subject but it still possesses great interest from the point of view of research.

It is not to be supposed that the provision of the new 24ft. tunnel at Farnborough will render obsolete or useless the smaller wind tunnels at the R.A.E. or the N.P.L. and, in particular, the compressed air tunnel. Each type has more or less its own special field in which it excels the others as regards economy of working, the time occupied in obtaining results or the accuracy and range of the data which may be obtained from it. Duplication there may be in the means of studying certain problems but from the comparison of results obtained by duplicate methods there may be derived valuable information of both a scientific and a practical nature.

(To be continued.)

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE CONSUMER.

SIR,—In an article in THE ENGINEER of December 28th by Frederick Jenny, there is displayed a consummate cunning which is typical of the way in which the financial experts mislead people and cloud the real issues of the economic situation.

Nearly every feature of modern "capitalism" is to be commended, the only factor seriously at fault is the financial control which is surely taking from capitalistic industry any semblance of "freedom."

The producer exists to satisfy the consumer. This "nutshell" truth will suffice as a good basis for simple argument, because it stands good under any set of conditions.

To-day, the producers of the world are equipped to produce creature comforts for mankind as never before in the history of the world, and yet the very excess of stores available (actually or potentially) is the cause of the breakdown of finance.

If producers looking for an outlet for their goods would only combine with consumers in want of the amenities of life to insist that finance be made to adapt itself to the facts of life, then almost overnight could we all begin to be affluent, with the prospect of increased and comfortable leisure ahead.

Under present-day conditions the consumer cannot have his wants supplied without money as a medium. Let us consider then some of the attributes of money.

First, money is an almost costless production because the few coins passing in the community are a negligible quantity compared with the amounts in notes and credit instruments by which commerce is carried on.

Then money is of no value in itself. The command it gives over goods and services gives it its useful quality and its glamorous attraction to the foolish.

In ordinary trade practice it is well to remember that money is continually being made and destroyed. It is important that this conception be accepted and grasped. Students are advised to read books by R. G. Hawtrey and/or "The Midas Delusion," by Professor R. F. Irvine, M.A. (Hassell Press, Adelaide, South Australia). For others an analogy may help.

Taking liberties somewhat with the scientific facts, one may imagine positive and negative energies reaching an electric device by means of the two separate wires from the dynamo. In the process of impact, as it were, in the light globe or motor, and in producing the desired effects, the two "streams" neutralise one another and cease to exist. Similarly, money is created for production and is cancelled in consumption, as the electricity (as such) is produced out of nothing and then ceases to exist.

Actually, the power company in such a case does supply something which is in itself definitely an asset to the consumer; but even so, it never presumes to have any say regarding the policy of the consumer, who can use the power available in forwarding any enterprise thought desirable.

It is definitely otherwise with the institutions who, when they supply an almost costless medium as money, act as if it were in itself a commodity and make an exorbitant charge for it. As these institutions have a monopoly of the business, industry is necessarily almost completely subservient to their wishes in the long run, however much "rope" is allowed in the tethering at times.

Meanwhile, the wants of people and the desperate needs of many are not met in spite of obvious facilities or stores waiting the word to produce, or to be moved over the counter.

We are so used to the idea that money is scarce and valuable that it may do us good to picture a very different state of affairs, just to get our minds loose from the stultifying effects of accepted conventions.

Imagine a country in which the people decide to severely standardise their ways so that general habits of life, the means of production and especially prices, are not allowed to alter. Then allow that each person is endowed with a miraculous power to create extra legal tender at the rate of £1 per day. What would happen? Consumers would be able to get all they required up to the limit of their fellows to supply them, and hoarding of money would cease to be a commendable habit.

But the ways of society refuse to "stay put," so this supposititious case is of no value except that it may help us to think first in terms of goods and services available and to resolutely refuse to allow that finance should ever presume to any *rôle* other than that of reflecting or honouring the free transactions between the people capable and willing to serve and the people who are desirous of accepting their offices.

The only function then of the authorities who control the issue of money is to make sure that the proper amount is made available (without appreciable charge) to facilitate and record the consumer's quest for, and acquiring of, goods and services.

A more realistic way is to think of all monies merely as tickets, and to picture these tickets moving in one way in production, and then in the reverse direction with the sign changed in consumption.

Ordinary people seldom think of money as other than coming to and going from them. In ordinary trade routine the banker is quite used to setting new money on its way in the business world (with a plus sign) to make production possible, and then to watching for its return with the minus sign attached so that the debt is thereby cancelled.

One of the most serious faults in the practice of the money makers under the present system is that new money is only released as a debt for capital expansion or new production.

Once we scrap this silly superstition and determine to issue the right proportion of new money directly to stimulate consumption, then commerce can pursue its ways unhampered by any fear that the plus and minus balance will ever be far from being exact.

Major C. H. Douglas has given us principles which, if accepted, will bring about this very desirable state of affairs.

C. H. ALLEN, A.M.I.E. (Aust.).

S. Australia, February 28th.

STANDARDISED WORM GEARING.

SIR,—The recent correspondence in your columns and your leading articles on the above subject appear to neglect the users' point of view in the matter of the rating of worm gearing. Whilst it is undoubtedly true that the manufacture of these gears with case-hardened and ground worms and hobbed wheels is, perforce, becoming a specialised business in the hands of a few firms, large numbers of what may be termed medium-quality worm and wheel sets (*i.e.*, medium-carbon steel worms with turned finish and wheels generated by fly cutter) are still being made by general engineering firms, and an authoritative rating will be of considerable use as previously available data were not satisfactory. The user also meets cases when he has to determine what loads may be placed on an existing gear, and, again, the proposed specification will give a much more satisfactory answer than was available hitherto. These two points cover the writer's personal needs, but to make the proposed specification meet them adequately, he would suggest that when it is issued, several improvements might be made in its make-up compared with the previous specification on spur and bevel gearing. A standardised calculation sheet, on the lines of that used for electrical machinery design, should be drafted and added to the specification; the writer has found that considerable practice has been needed with the previous specifications to use them expeditiously, as the method of binding the charts in folded form along with the text is cumbersome in use, added to which they rapidly become torn and disfigured with pencil marks in finding coefficients, this applying particularly to the charts of Zone Factor and Strength Factor. It is suggested that these charts should be published on a much better quality paper with stiff backing, unfolded and bound up separately to the letterpress, which could have its own set of charts, as a present, for completeness if desired. Thus, these charts could be cleaned periodically or, better still, a sheet of tracing paper (renewable) could be kept over each.

Subject to the above difficulties, I have found the previous specifications of material value and find the data given in Dr. Merritt's paper as a prelude to publication to promise equal satisfaction in the case of worm gearing.

It is interesting to note that in all the cases the writer has checked with this latter, that the controlling feature on rating is the wear of the worm wheel, which is always very considerably lower than that of the worm and of the strength of either wheel or worm and encourages one to ask what possibility the future holds of making the wear of the worm wheel more nearly accord with its strength and that of the worm.

G. VARLEY.

Huddersfield, April 1st.

[We have not questioned the inherent value of the Worm Gear Specification. It is the propriety of making it a "standard" that we have questioned.—ED. THE E.]

HIGH-SPEED TRAINS.

SIR,—Whenever this subject is reopened it produces a number of amazing allegations as to past records. A typical example is afforded by Mr. H. Ravenshaw's letter, which appears in your current issue. According to his observations, "speeds of 90 miles an hour were regularly recorded" between Corby and Peterborough during the years 1885 to 1890.

In point of fact, it is extremely questionable whether such a speed was within the powers of any locomotive then in existence, simply because the exhaust port areas were too small to avert excessive back pressure. When a speed of 90 m.p.h. was recorded by Mr. Charles Rous-Marten, with a Midland single-wheeler of more modern design than the G.N. engines, emphasis was laid on the freedom of the exhaust. Incidentally, I believe I have read that repeated efforts with the same type of locomotive consistently failed to reproduce the performance, even under optimum conditions, so that the fact must have been due to an isolated concurrence of every favourable factor. It remained unique for many years, and although from about 1898 onwards one heard of an occasional "ninety" being observed on the Salisbury–Exeter section of the L. and S.W., such maxima remained altogether exceptional until well into this century. Even now, though not so rare as to cause excitement, they are by no means common; one could travel by a series of the fastest British expresses for days or weeks, and not get a "ninety." Having constantly to travel, and having "clocked" some 200,000 miles, I can speak from adequate experience.

In the light of these considerations, it is next to a certainty that the trains timed by Mr. Ravenshaw in the late 'eighties were not regularly attaining 90 miles an hour, or, indeed, ever doing so. It may be that a wrongly placed milepost on the "galloping ground" was to blame; such things were by no means unknown in the old days, and I remember several which gave startling figures. If Mr. Ravenshaw could adduce station-to-station times on some of the trips they would throw light on the matter. I should expect them to correspond with maximum speeds little, if at all, in excess of 80 miles an hour.

HORACE MYERS, Major.

London, N.W.3, April 2nd.

"UNEMPAYMENT" AND ENGINEERS.

SIR,—As an engineer, producing apparatus in connection with public works, such as sewage disposal, water supplies, &c., I am particularly interested in the letter in your issue of March 29th under the title of "'Unempayment' and Engineers," and over the signature of K. W. Willans.

I also was at the meeting at the Central Hall, Westminster, to hear Mr. Gibson, of Sheffield, speak on "Social Credit," and it seemed to me that he attacked the real roots of the present growing inability of both individuals and the community as a whole to secure those improvements in their social and communal life which physical conditions make easily possible.

Public works of all kinds, both to increase the health and amenities of the community, are urgently required—a water supply grid system is probably more necessary than the electric grid system, but these improvements, both communal and individual, are held up by an artificial money shortage.

Your readers may have been interested in hearing, or reading in *The Listener*, the broadcast "Conversation in a Train" of March 13th, entitled—"Where Does Invention Lead?" The chief speaker in the conversation was an inventor. He had invented a machine for use in coal mines which would double the present output with less than half the present labour. He pointed out that if he sold his invention it would destroy the livelihood of 50,000 men and their families, and if he did not sell his invention he would starve, because he had put every penny he had into it. And he pointed out that an inventor must invent what is in him, just as a poet must write, or an artist paint what is in him. He summed it up by saying that we are gradually approaching a situation when machinery is steadily doing away with the need for human labour. Suppose that in another hundred years we require only one million workers to supply the requirements of the whole population, shall we all have to starve,

or rub along on a dole levied out of their wages, and if not, how are we to live ?

This point of view was emphasised by a subsequent "Conversation in a Train" broadcast on Saturday, March 30th, when an advertising agent declared that the great expenditure on advertising created work for large numbers of people. Surely these two ideas are contradictory one of another ? It is becoming generally accepted that the volume of purchasing power is determined and restricted by our banking system, and the greater the proportion of this money expended in advertising services the less will remain for purchasing the products of industry and agriculture.

When the gap between production and consumption is bridged by some such method as the Douglas social credit proposals, the natural demands of the individuals or the groups will be quite capable of issuing instructions as to the products which are required from the engineers.

London, March 31st. Jas. Edw. Tuse.

Sir,—You have earned the gratitude of a small, if scattered, section of the profession by your catholicity in publishing Mr. Willan's appeal on behalf of social credit in to-day's issue.

After twenty-five years' experience in the rank and file, one cannot be suspected of harbouring any illusions as to the loyalties which actuate the heads of the profession.

A profession that lacks any organisation to protect the interests of the rank and file of its members, and which makes no attempt to regulate the conditions which are imposed on them, is not the healthiest field for the social credit germ.

On the other hand, no one should be better fitted than the engineer to appreciate to the full the implications of social credit in regard to costing accountancy and the tremendous impetus the national dividend would give to engineering, in all its branches.

I venture to hope that your columns may attract a lively correspondence upon this vital subject.

March 29th. Esprit de Corps.

The Bend Test, and Its Value as a Guide to Ductility.*

By L. W. Schuster, M.A., M.I. Mech. E.†

Introduction.

Considerable scientific study has been devoted to the tensile and other forms of mechanical test, but the bend test, though one of the most useful, has escaped any such treatment, with the consequence that it is, as often as not, carried out in a slipshod manner that leads to fortuitous results and gives little or no knowledge of the properties of the material. The paper correlates the ductility shown by tensile and bend specimens, and enables the ultimate performance of a bend specimen to be foretold with reasonable accuracy. It gives a large amount of data that may be found useful in preparing specifications.

Owing to the complexity of the problems involved in plastic bending, the subject does not lend itself to theoretical treatment, but by the use of empirical data very simple formulæ can be derived, sufficiently accurate for applying to commercial tests and correlating various test conditions with one another. The results given by the more usual forms of bend test are analysed, and the special characteristics of the tests are described. Several methods of carrying out tests are shown to be faulty and to lead to unnecessary straining of the metal: consequently, widely different results are obtained by different operators working to the same specification. Suggestions are given for designing the most suitable apparatus and for modifying methods of test, to improve results and to overcome inconsistencies.

The special problems involved in making a bend test on a welded joint are also discussed, and recommendations or tests are made. The ductility developed by such a test is also correlated with the ductility shown by a tensile test on the weld metal itself.

Part I: Technical Interpretation of a Bend Test.

The Use of the Bend Test.—The paper applies principally to the use of the bend test for determining the ductility of steel, though the test also affords a ready means for detecting local faults.

Apart from any theoretical considerations, it is desirable for the preparation of specifications that some basis should exist on which the radius of bend can be stipulated, and also on which the requirements can be modified to suit particular conditions. As an example, in a specification for plates it has been found necessary, in order to suit manufacturers, that the width of bend specimens should always be 2in.; the ratio of the width of the specimen to the thickness of the plate, which may not be machined at the surfaces, may thus vary between, say, 1 and 5·3. The severity of the test, since it varies with this ratio, can be kept constant only if the internal diameter of the specimen is modified to suit. Some means is therefore necessary for determining the correct relationship. The solution to this and similar problems is easily obtainable from the simple relationships that are reached.

The Value of w_2/w_1 for Specimens of Different Width.‡—Preliminary experiments on steel showed that when $W = t$, lateral contraction at the extrados is approximately free, narrower specimens being unstable laterally. The same was found for rubber lightly strained—a material altogether unsuitable for further experiment. When W was increased to about $5t$, the contraction of steel specimens appeared to be totally restrained at mid-width.

The experimental figures were first plotted to a large scale, and then re-plotted in the curve, Fig. 1.

The Relationship Between t_{f_0}/t_{f_1} and ε.—The appropriate formula for determining the value of t_{f_0}/t_{f_1} by use of the values for k is developed in an appendix, where other useful relationships are also given. From these the family of curves given in Fig. 2 has been plotted, showing the relationship which the elongation of a bend specimen of any width bears to the tensile reduction in area. It also gives the corresponding value of D for several peaking ratios, and of the radial strain at the outer fibres, *i.e.*, $(t_{f_0} - t_{f_1})/t_{f_0}$, though the value of this quantity is an arbitrary criterion for determining the severity of a test.

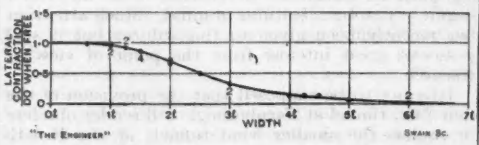


Fig. 1—*Relationship between Lateral Contractions of specimens of different width (e_A = about 70 per cent).*

The figures represent the number of specimens.

Though strictly the values of k given by the curve apply only to specimens in which e varies between 65 and 80 per cent., they may be used within a wide range for commercial testing, the error being inconsiderable.

Close Bends.—Contrary to a commonly accepted conception, based on elastic formulæ for bending solely by means of an applied moment, the actual value of ε for a close bend usually falls considerably below unity. The actual elongation developed by a specimen of given material, when bent close, varies considerably, depending partly on the method of bending and partly on the extent to which collapse takes place and compression cracks are set up at the intrados. When a former has been used, the result may also be affected by the crushing of the inner fibres. The severity of the test may thus be a variable factor when a close bend is specified. Typical figures are given in Table I, showing that for a given value of W there is a tendency for e to increase with t, and that for a given value of t there is a tendency for e to decrease when W is increased, which, unfortunately, detracts from the severity of the test. Table II shows that e increases with the hardness of the material and particularly with cold work.

Table I.—*Close Bends: Change in Percentage Value of e for Mild Steel.*

Thickness of specimen in.	Ratio of width to thickness. 5/1.	3/1.	1/1.
0·10	60	63	72
0·25	65	68	75
0·50	65	68	78
0·75	—	—	80
1·0	74	75	84*
1·25	—	—	86
3·0	—	—	103
Red-hot steel 1·0in. thick	75·1	—	74·1

* 79 per cent. for a round specimen.

Tests to the Point of Failure to Show the Relationship Between r and e.—Rough measurement of the curvature of cracked bend specimens confirms at once that there is a very fair agreement between the actual and calculated values of e. For an absolute comparison it is necessary to stop the test the moment the smallest crack breaks out, and to obtain an accurate measurement of the cracked specimen. Such tests require careful choice of the material, as, when bent, very ductile material does not break at all; a ductile material breaks only when W is large; hard material may fail prematurely at a gauge line; heat-treated material may be affected by internal stress; and any steel, especially castings, may contain local defects. In view of the assumptions made and the vagaries of test, the figures giving elongations for the first crack to break out, show that agreement is generally much closer than might be expected. The only radical departure was shown by a high tonnage steel, and the same tendency was shown by the high carbon steel of which the readings were not always reliable. The inference is that steels of low ductility develop a value of e higher than that calculated. Work hardening seems to affect the relationship found for an austenitic steel.

Table II.—*Close Bends* (1in. *by* 1in.): *Change of e with Hardness.*

Quality of steel.	Brinell No.	e_A, per cent.	e_A/e_t.	$e_A/e_{0\cdot5t}$.
Carbon	111	91·3	1·06	1·03
Carbon (cold-worked)	163	113·3	1·27	1·07
Nickel-chromium	248	122·5	1·17	1·14
,,	351	130·2	1·25	1·05

Fusion-welded butt joints invariably contain pores, and agreement between the tests is not to be expected from defective material, but, provided that the weld metal is of good quality, bend specimens cut from welded joints initiate cracks when the radial strain is quite close to that calculated from tensile tests on bars consisting entirely of weld metal, *i.e.*, when the metals and the heat treatment are similar.

When a specimen is round, it is not possible to make transverse measurements at the outer fibres, for use in determining the radial strain. Again, unless the metal is ductile it is not possible to induce fracture, or to compare the value of e for round and rectangular specimens at the time of fracture. For material of relatively low ductility, however, round bend specimens can, without fracturing, be strained more than is to be expected from the tensile figures; the high value of e compared with that given by square specimens confirms that this is not an idiosyncrasy of the particular steels used, and that it presumably applies equally to ductile material. It would seem that the explanation is due to a more complex flow of the fibre in round specimens.

Part II: Methods of Carrying out a Bend Test.

General.—In the common methods used in making a bend test two or more forces are usually applied. For this reason alone the value of p for specimens of similar material tested in different manners may vary appreciably, even if each form of test leads to true circularity at the intrados of the specimen.

Steadily Applied Pressure versus Hammer Blows.—Specifications usually allow bending to be carried out by blows from a hammer; under certain circumstances, however, the results are said to be improved thereby,

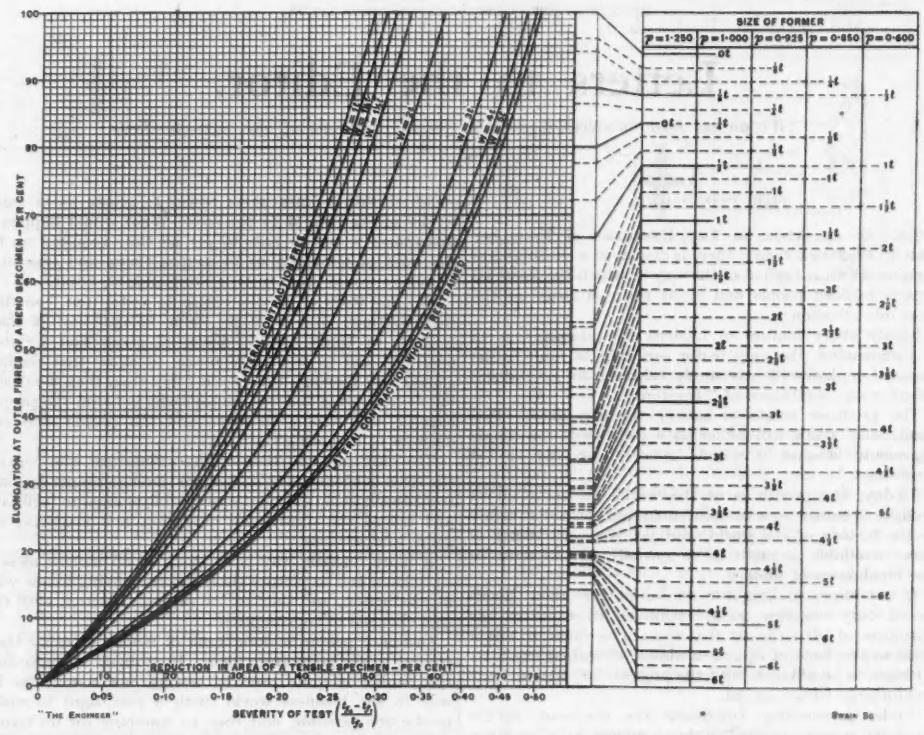

SIZE OF FORMER
p = 1·250
p = 1·000
p = 0·925
p = 0·850
p = 0·600
ELONGATION AT OUTER FIBRES OF A BEND SPECIMEN – PER CENT
LATERAL CONTRACTION
REDUCTION IN AREA OF A TENSILE SPECIMEN – PER CENT
SEVERITY OF TEST
"The Engineer"

Fig. 2—*Relationship between the Diameter of the Former and the Width of a Bend Specimen for any given severity of test.*

Table III.—*Forged Steel Specimens* 1in. × 1in.

	Steady pressure.					Intermittent blows.				
Specimen No.	1	2	3	4	Average.	1	2	3	4	Average.
Greatest percentage elongation	60·0	63·3	61·7	62·5	61·9	60·0	60·0	54·0	56·0	57·5
Angle of bend, deg.	161·5	172	166	167	166·5	172	151	155	148	156·5

* The Institution of Mechanical Engineers, March 26th.—Abstract.

† Technical Adviser, British Engine Boiler and Electrical Insurance Company, Ltd.

‡ For list of symbols see Appendix.

because the use of intermittent blows allows the metal time to recover if it becomes locally distressed. The following experiments were therefore made.

Four specimens of a forged steel containing 0·45 per cent. carbon were bent by steadily applied pressure, and four by light blows with a press, in between each of which there was a short interval, the free-bend method being applied similarly to each, and bending being continued until first failure. The results are given in Table III. The slightly lower result caused by the blows was evidently due to impact.

A wrought iron forging, representing a heterogeneous material, was similarly tested, the specimens being cut out as far as possible from the same pile and then normalised together. They were all bent through 180 deg., and the limbs afterwards pressed together. The results, given in Table IV, were by no means decisive, owing to

TABLE IV.—*Wrought Iron Specimens ¾in. × ¾in.*

	Steady pressure.					Intermittent blows.				
Specimen No.	1	2	3	4	5	1	2	3	4	5
Greatest percentage elongation	—	85	82	—	—	75	72	67	—	—
Gap between limbs, inches	1·0	0·17	0·10	0·6	0·4	0·6	0·85	0·4	0·2	0·3
Remarks	Crack	No crack	Crack at edge	Crack	Crack	Cracks at edges			No crack	

too great ductility and to the tendency for cracks, which may have been premature, to start from the edges.

For the results in Table V, furnished to the author, the specimens were pressed into lead. The improvement due to the use of blows was ascribed to the release of the direct tension, between the blows.

TABLE V.—*Internal Diameters.*

t=0·016in. Ultimate tensile strength=90·8 tons per sq. in.

Steady pressure	5 t	4 t
Heavy blows	4 t	3 t
Light blows	—	3 t
Very light blows	3 t	—
Result	No cracks formed	Cracks formed

A. *Free Bend Test.*—For this test bending can be started in any one of several ways, exemplified in Fig. 2A. For the ordinary method, *a*, *b*, or *c*, a set is first given by the pressure of a former or by blows on a bar. For *d* the ends are first given a set at fixed points; the test was originally introduced in America for fusion-welded joints and is referred to as the A.S.M.E. method. The perform-

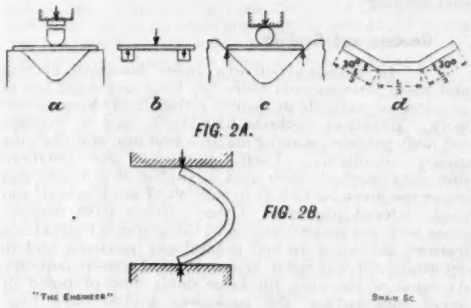


FIG. 2A.

FIG. 2B.

FIG. 2A—*Methods of Starting Free Bend Test.*

FIG. 2B—*Method of Bending by Lateral Pressure.*

ance is judged by the stretch at the outer fibres, and a constant gauge length equal to 1 t is suggested for the measurement, as the elongation ratio is of importance.

After the specimen has been given an initial set, it is placed on end and bent by lateral pressure, as shown in Fig. 2B. After 180 deg. is attained, bending can be continued in different manners. By method *a*, e_A reaches 32·1 per cent.; by method *b*, 51·6 per cent. when $g=2\,t$; by method *c*, 45·0 per cent. when $g=2·1\,t$. Very different results may thus occur, with variations even greater than that shown.

Summary.—When the conditions of bending are closely defined and the same material is used, the strain for a given angle of bend is not necessarily constant. Likewise, the assessing of the strain from the value of g, whether the limbs are straight or curved, is liable to lead to error. For the A.S.M.E. test, L should be kept as short as convenient. In the ordinary test, when α just reaches 180 deg., e is decreased by increasing any of the following quantities:—(*a*) L, W, or t; (*b*) D, for the initial set; or (*c*) the angle of the initial set, *i.e.*, when D is not unreasonably small.

B. *Bending on Supports Solely by means of a Former.*—This method is of the greatest importance and may be made one of the most efficient; its study is therefore imperative (*a*) to prevent undue straining of specimens during routine tests, a common occurrence; (*b*) to guide inspectors and to assist framers of specifications. Though the apparatus required is simple, the usual design is poor, leading to limited use. A tensile test machine if suitably designed can always be used for applying the load.

Some varieties of the apparatus required are shown in Fig. 3. The sketches *a*, *b*, and *c* show fixed supports. In *a* the value of α can reach about 90 deg. only; in *b*, 180 deg.; and in *c*, r is gradually reduced as the test proceeds; this so-called "easy" start of the bending is erroneously supposed to benefit the specimen. In *d* rollers intended to reduce friction are fitted. Diagrammatic representation of designs in which the distance N is adjustable is given by the later sketches. In *e* two bolts take the thrust and allow lengthwise adjustment. This design, though crude, allows the efficient bending of a large range of specimens. In *f* is a more rigid design fitted with rollers. In *g* packings within rigid headstocks replace adjusting screws, allowing speedy adjustment. In *h* rollers of different size can be used. In *i* the distance M is fixed, but c is changed by altering d; this erroneously leads to larger rollers for smaller values of t and D; the reduction in p which results is, of course, immaterial if the performance is judged by measurement of e, as for welds. In *j* the supports can rock, causing a gradual reduction in c during the test; this is akin to the gradual reduction of the radius, as in *c*. In addition, a pin is threaded through wings on the faces of the former and passed under the middle of the specimen, to limit movement of the crown of the specimen away from the former. A good design should allow quick and convenient operation and a speedy adjustment of c; for a bend of 180 deg. there should be an opening in the base to allow the specimen to be forced right through the rollers. Adjusting bolts can be fitted with right and left-hand threads, to move the supports simultaneously and to keep the value of c the same at either side of the former. Rollers of four different types were tested; these are shown in greater detail in Fig. 4, while the method of measuring the horizontal clearance is shown by Fig. 5.

The test involves a large number of variables, and an attempt to determine the effect of each combination would be an enormous undertaking. The aim of the tests was therefore to determine approximately the best values for the various dimensions, to ascertain the values of p obtainable under favourable conditions, to settle controversial points, and to analyse the working of certain leading specifications. Particular study was made of the value of α when e_A ceases to increase; this information is important in preparing specifications. For convenience, all dimensions are given in terms of t, but it does not follow that the resulting values of p are constant for any value of t. Though when supports are circular the radial clearance changes in a complex manner during the bending, the treatment given here, where the effect of altering c and d are studied independently, gives sufficiently accurate results for practical purposes. When the value of α is comparatively large, so that the deformation is more than local, the springing of the specimen when removed from the machine represents mainly the release of strain away from the crown of the specimen, and it is doubtful if the reduction in e_A is ever more than negligible. Very hard material stressed *uniformly* over a long length, however, shows a release of strain.

The results of representative comparative tests are given in a series of tables; in making these tests only one factor was varied at a time. The findings are given under the following headings:—

Quality of Material.—Increasing the hardness of steel, or, in particular, cold working reduces the value of p. Extensive experiments would be required to investigate the mechanism of all such changes. The value of the yield point and the work-hardening capacity of the material are, however, important considerations.

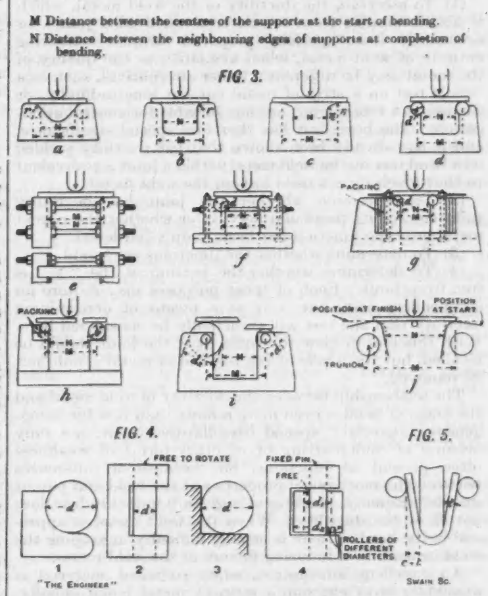
Clearance.—A limited increase in c always tends to lower p, the fall being sometimes appreciable. This is due to inferior bedding on the former. Even if c is reduced to zero, the value of p never suffers a reduction. In practice, a working margin is desirable to prevent undue wear and tear and to limit the load. As an all-round figure 0·10 t is recommended, but 0·05 t is better if it is desired that α should approximate to 180 deg. There is a tendency for a reduction in c to cause a more even strain near the crown of specimens, *i.e.*, to improve the value of e_A/e_t. An increase in c naturally decreases α, but when a bend of 180 deg. is required, the angle resulting from $c=0·05\,t$ should be sufficiently near 180 deg. to satisfy even an exacting inspector, under the false impression that the angle of bend is a matter of significance. Actually, if α is comparatively small because c has been excessive, the tendency will be for e to be larger than the normal.

Rotating versus Non-rotating Rollers.—At first comparative tests were made with similar fixed and free rollers, d varying between ¼in. and 5½in. These tests were futile, for none of the rollers used rotated. In later tests, partial rotation was occasionally experienced, but then generally after e had reached a maximum value. In the occasional instances where there was early rotation, either c or r was excessive and p was unduly low. The results show that an increase in friction, so far from being harmful, always tends to improve p, detracting from the value of rollers, *i.e.*, if the bearings allow rotation. Next, a specimen was forced through supports with hardened knife-edges, the clearance being almost negligible; this caused the limbs of the specimen to be unmercifully cut up by the sharp edges; as a result e_A was lower than with a normal value of c, and e_A remained situated at the crown of the specimen. Next, a specimen ¼in. thick was forced through a machine of type *j*, Fig. 3, designed for specimens only ⅜in. thick, resulting in a severe drag on the limbs and considerable reduction in their thickness; as a result, the peaking ratio was raised from 0·797 to 0·920. The drastic treatment caused no ill effect except away from the crown, and thus tended to improve the ratio e_A/e_t. Abrasure at the outside of the limbs of a specimen is therefore no detriment. At last full rotation was found with certain rollers of type 2, Fig. 4. The only change resulting from replacing fixed by rotating rollers was an insignificant improvement in the ratio e_A/e_t and a slight falling off in the load.

Any advantage in the use of rollers lies in: (1) A reduction in the load and in wear and tear, but in the latter only if the rollers rotate when the load is high; (2) their easy replacement when worn; (3) possible convenience in design; (4) their interchangeability providing a ready means of changing N, but not necessarily in an efficient manner; (5) their providing a ready means of maintaining r proportionate to t; and (6) their affording a ready means of introducing hardened supports.

Effect of Altering r.—Clearly, rotating and fixed supports may be treated together. Since, as will be shown, e_A does not increase after α reaches, say, 90 deg., any lowering of p due to a high value of c takes place earlier. As increasing r is equivalent to increasing c at the earlier part of the test, it is to be anticipated that an increase in r will be harmful. A limited increase in r reduces p, and d should preferably be kept below 1 t. A smaller figure still may be beneficial, but the load will naturally be increased; even if d is reduced to ½ t the wear and tear of well-hardened parts will not be excessive.

Effect of Variation in c and r, while (c+r) Remains Constant.—Assuming ideal bending through 180 deg. and neglecting clearance at the end of the test, the final mean length of the arc Q of the specimen exceeds the initial active length M by $(0·57\,x-0·43)\,t-2\,(c+r)$. A negative value of this difference in general tends to greater spring of the specimen away from the former and a low peaking ratio. The expression explains partly, but by no means



FIGS. 3-5—*Various Types of Apparatus for Bending on Supports by Means of a Former.*

wholly, why $(c+r)$ should not be large. For low values of $(c+r)$ no appreciable change in the value of e was found, but high values of c reduced the load more than the high values of r.

Thickness of Specimen.—For a series of tests t was varied, all other dimensions being maintained proportional to t. They showed a small reduction in p with increase in the thickness of soft steel; with hard steel, collapses sometimes obscured any such tendency.

Width of Specimen.—Increasing W above 1 t improves the value of p. Experiments with t increased to 1in. showed abnormal results, e reaching a maximum at either side of the crown of specimens with a width greater than 1 t. Further investigation is required.

Round versus Square Specimens.—It appears that round specimens attain a high value of p more readily than square specimens. Moreover, for an equal value of e, the distress of the round material is less.

Former Diameter.—With soft steels and low values of d a low value of D improves the value of p, but as the steel becomes hard the reverse occurs.

C. *Bending on a Mandrel.*—This method of bending requires simple apparatus only, and is specified principally for bending thin material of low ductility to a relatively small angle. As the strain eventually becomes uniform over a long length the method approaches the ideal, *i.e.*, so long as D and α are sufficiently large for true bedding, and suitable means of stressing are employed. With thin specimens the test can be made quickly in an ordinary vice. Commercially the specimen and the mandrel are usually held together under a steam hammer, and bending is effected by blows or some special device. It is not always easy to apply the necessary force sufficiently near the point of contact of the specimen with the mandrel; the shorter this distance is made, the shorter the leverage and the greater the resulting damage to the specimen at the tension side; equally, the greater the force, the greater the damage to the intrados, where the reaction acts at a progressively changing point. During the present tests it was essential that no damage should occur at the calibrated part of the extrados.

Summary.—Provided that the means of bending are such that the load is applied at a distance of not more than 2 t from the last point of contact of the specimen with the mandrel, commercial tests need not be continued after α reaches 100 deg.; after this any increase in e_A is fortuitous. If a hammer is used the value of e_A may be raised or the specimen injured. When D is less than 3 t the results for any steel are liable to vary.

For small values of α the relative value of e and α is variable; bending through angles less than 90 deg. is therefore not recommended. For material of low ductility α should be not less than 100 deg., the size of the mandrel being increased accordingly. When the diameter of the mandrel lies between 3 t and 5 t, p attains a value of 0·925 in a well-conducted test.

D. *Bending by Pressing the Specimen into Soft Metal with a Former.*—This method of bending overcomes the peaking of hard material bent with large formers; though it was introduced for sheet metal, the author has used it successfully on material ¾in. thick. An ordinary former is used, but the specimen, instead of being mounted on solid supports, is pressed into a soft metal, such as lead. The

surrounding lead tends to cause close contact of the specimen with the former, but the crown of the specimen is thereby strained radially. With the load applied in this manner a comparatively low value of α suffices for the test.

E. *Bending by the Application of a Pure Bending Moment.*—This form of test is theoretically the ideal and is, of course, much used for the transverse test; but, so far as the author is aware, has not been used for large deformations in this country. No force other than a pure bending moment is applied; consequently the whole of the loaded length becomes circular. With this method of loading an advantage is that the curvature and the strain increase continuously with increases in α, but for a given value of D a lower value of e is to be expected than from other methods. The method is particularly applicable to non-uniform material, such as a welded joint, as it tends to enforce fracture at the weakest section, instead of at the section of maximum strain.

F. *Bend Tests of Fusion-welded Joints.*—The bending of welded joints is a specialised problem, and the functions of a test, beyond showing up defects within the metal, are fourfold:—

(1) To ascertain the ductility of the weld metal, which is not obtainable from tensile tests on welded joints, or necessarily from specially prepared samples consisting entirely of weld metal, when available, as the quality of the metal may be different. Other alternatives, such as a tensile test on a strip of metal cut out longitudinally, or the use of a tensometer, are not suitable for general application. The bend test has therefore special significance, and it has already been shown that the ductility yielded on a bend test by the weld metal within a joint is equivalent to that given by a tensile test on the weld metal.

(2) To determine whether the joint has flexibility sufficient for its particular service, or whether the parent metal near the junction has been unduly hardened.

(3) To determine whether the junctions are sound.

(4) To determine whether the bottom of the "V" is free from fault. Each of these purposes may require an independent test, but it is as a means of determining ductility that the test will principally be considered here. With this aim in view the surfaces of the joint should be levelled, but the whole of the top run of metal should not be removed.

The relationship between the ductility of weld metal and the angle of bend is even more remote than it is for homogeneous material; special irregularities occur, not only because of undercutting or of other forms of weakness often present at junctions, but because of differences between the mechanical properties of the weld and parent metals. Equally, bending to a given nominal radius does not show the ductility. When the weld metal is appreciably the harder, there is usually difficulty in keeping the weld central or in inducing flexure of the weld metal.

An excellent alternative, when sufficient material is available, is to cut out a strip of metal longitudinally. Such a specimen, being uniform along a given axis, may be tested by ordinary methods; the direction of the strain is, however, incorrect for testing the joint as a whole. The weld metal is kept at mid-width, and the specimen may consist of weld metal only, or of weld metal with parent metal at either side. The severity of test is the same as that of a homogeneous specimen with W similarly proportioned to t.

Summary.—A bend test on a welded joint affords an excellent means of assessing the ductility of the weld metal. For the test a strip of metal is cut out longitudinally and tested in the ordinary manner, or if the weld metal is not appreciably harder than the plate the ductility is determinable from measurements on a series of gauge lengths.

For a commercial test the most convenient means of testing for minimum ductility is to measure the strain e_t developed by a transverse test piece. There are, however, three qualifications: (*a*) the relative properties of the weld metal and the plate must be such that the desired strain can be set up by a transverse test; (*b*) failure outside the gauge points should be disregarded; and (*c*) the greatest strain within the weld metal will always exceed e_t. In gauging the quality of weld metal allowance should therefore be made for the normal excess of e_A. For an abnormal rise the weld may well lose credit, as it will be due to local defect or unsuitable matching of the metals.

General Summary of Some of the More Important Findings.

(1) Ductility as shown by bend and tensile tests can be correlated with sufficient accuracy for commercial testing. Fig. 2 gives the full relationship for rectangular bend specimens, and other data useful in the preparation of specifications. Steels of low ductility have alone shown appreciable deviation.

(2) The curves also show the relationship between the severity of a test and the width of the specimen. When the ductility is high the strain required to form a crack in a narrow specimen reaches three times that required for a wide specimen, and when the ductility is very low twice the strain is still required.

(3) Formulæ given in an appendix to the paper (not reprinted here) afford the solution to many special problems.

(4) The elongation given by a close bend decreases when W is increased or t reduced. Its value increases with the strength of the material.

(5) When soft material is bent by suitable means, the strain for values of D down to 1 t can be computed with reasonable accuracy, without measurement.

(6) When material has a relatively high yield point, especially when the radius of curvature is small, the value of p is uncertain and the usual commercial test affords only a rough criterion of ductility.

(7) Empirical values of p and e are given for the more usual methods of bending.

(8) After a specimen has been bent to a given radius, a test should not be continued till the limbs touch.

(9) The performance of a bend specimen should not be gauged from the distance apart of the limbs, when either straight or curved. It may, however, be gauged roughly from the minimum internal radius, if this is not less than $\frac{1}{2}t$.

(10) When the load is removed from a bend specimen and the limbs spring apart, any reduction of e_A is usually insignificant. The spring represents the relief of strain away from the crown, and lowers the ratio e_A/e_t. Springy material bent uniformly over an appreciable arc is probably the only exception of importance.

(11) A small angle of bend should not be specified. Results from such tests are reliable only if material of given grade has been bent by a pure bending moment under defined conditions.

(12) The following conditions apply to bending on a former:—

(*a*) For efficient results c should not exceed $0{\cdot}10\,t$, and r should not exceed $0{\cdot}5\,t$.

(*b*) For any given setting of the apparatus hard material is always strained more than soft material.

(*c*) Hard material springs appreciably away from the former, and results are not only erractic, but do not allow ready interpretation. The difficulties in devising a satisfactory method of bending narrow specimens on formers with a small value of D appear to be insuperable.

(*d*) Rotating supports are superfluous for reducing the value of p.

(*e*) Reducing the thickness or increasing the width of specimens improves the value of p.

(13) In any method of test there is no need for α to reach 180 deg. Bending with a former need not be continued after 120 deg. is reached, or bending on a mandrel, when correctly performed, after 100 deg. Where, however, the free bend test is adopted, the final internal diameter should not exceed the prescribed diameter.

(14) The ductility of the weld metal within a fusion-welded butt joint is readily determined from a bend test. If no measurement of strain is made, the specimen must be cut out longitudinally from the joint.

(15) Bending a welded joint to a prescribed angle, or bending such a joint through 180 deg. with a former of given size gives no indication whatever of the ductility of the weld metal. For a commercial test on a transverse specimen, measurement of the elongation is essential, and the limitations of such a method are described.

APPENDIX.

List of Some of the Symbols Used.

t_o, l_o, and w_o Original thickness, length, and width of an element at the extrados of a bend specimen.

t_f, l_f, and w_f Final thickness, length, and width after it is strained.

t, W, and L Thickness, width, and length of bend specimen.

a Coefficient in measurement of the outside radius.

x Coefficient in measurement of the diameter of the former.

y Coefficient in measurement of the gap between the limbs (see g).

g Width of gap (in terms of t) between the interior of the limbs of a bend specimen after 180 deg. is reached. If limbs are parallel, g to be measured at the parallel portion; or if curved, at the greatest distance apart. If a distance piece is used, the measurement to be that of the distance piece, *i.e.*, yt.

D Diameter of the former used for bending, in terms of t, *i.e.*, $x\,t$.

r and d Radius and diameter of the supports (Part II of the paper only).

c Clearance per side between the former and the supports, after deducting the thickness of the specimen.

r Fractional reduction in area at the neck of a tensile specimen (Part I of the paper only).

z Fractional longitudinal strain at extrados of a bend specimen.

e Percentage elongation at extrados of a bend specimen.

e_t Measured percentage elongation on a gauge length of 1 t at extrados.

e_A Actual percentage elongation at or near the crown of the extrados.

p Peaking ratio when the mean radius at the crown is computed from a determination of the elongation; that is, ratio of computed strain at the extrados to the actual strain at the crown of the extrados.

$\frac{e_A}{e_t}$ Elongation ratio when the maximum strain occurs near the mid-section; shows the degree of peaking on a central gauge length equal to 1 t.

α Total angle through which specimen has been bent.

American Engineering News.

Welding Effect on Steel.

An important point for consideration in the welding of steel structures is the effect of the welding heat on the character or properties of the steel. In heat treatment of steel precise knowledge of the effect of heat has made it possible to prepare specifications and instructions which will produce definite results; but in fusion welding the steel adjacent to the weld is raised rapidly to the fusion temperature and then cooled at a rate which is practically uncontrollable. Laboratory tests in America—by oxy-acetylene welding—have been made to determine the effects on the zone of metal directly adjacent to the weld. These do not include the fused metal of the weld proper, as this has already been studied and the character of the metal is well known. The principal conclusion is that the heat of welding produces no notable metallographic effect, except that in the zone immediately adjacent to the scarf the ductility is reduced, but the tensile strength is increased. This effect can be eliminated, however, by local normalising, if that should be desirable. The minimum tensile strength in a welded joint is in the zone subjected to the maximum sub-critical temperature, but this does not necessarily reduce the strength of the joint. This zone can be eliminated by general normalising. But the high ductility in this zone, together with its slight decrease in tensile strength, permits its use at the same stress as that of the plate itself. In commercial plate used for welding, strain-age brittleness may be produced by cold working before welding, or by internal stress due to the combination of restraint and steep temperature gradients during welding. This condition can be eliminated by general stress relieving. Steep temperature gradients may do permanent damage to the steel. But in oxy-acetylene welding such steep temperature gradients are not produced, and in other methods of welding the unfavourable effects may be largely avoided by proper design. Preheating the entire member to be welded is one way of eliminating steep temperature gradients.

Wrought Iron and Steel.

Nickel-wrought iron as a relatively new development in iron and steel alloys is now being produced on a commercial basis in the United States, following the now well-known and widely used nickel-cast iron. The nickel content of the wrought iron may be as high as 5 per cent., but for commercial purposes about 3 per cent. is usually the maximum. The pig iron is melted in a cupola and after a desulphurising process is refined in a Bessemer converter. The nickel is added to the molten iron. In chemical composition the alloy is much the same as ordinary wrought iron, except for the nickel addition. In physical characteristics the yield point and tensile strength are raised considerably, with very little decrease in the ductility. Thus, the yield point for the nickel wrought iron is about 45,000 lb. per square inch, as against 30,000 lb., and tensile strength 60,000 lb., as against 48,000 lb., while the elongation on 8in. is 22 per cent. instead of 25 per cent., with a reduction in area of 40 instead of 45 per cent. Hardness and resistance to impact are increased, while resistance to cold bending is reduced. Water quenching temperatures should not exceed 1550 deg. Fah., followed by drawing at 750 deg. Particular interest in sheet steel for high strength has followed the recent commercial developments in such steel, and its use in light-weight railway rolling stock. In some grades the yield point is 70,000 lb. to 85,000 lb., the tensile strength 90,000 lb. to 105,000 lb., and the elongation is 20 to 26 per cent. in 2in. For such steels a fibre stress of 35,000 lb. is held permissible, giving a factor of safety of 35,000 lb. before permanent set. On a section ¼in. by 1in. the safe working load would be 4375 lb. and failure would occur—due to permanent set—at 8750 lb., while for structural steel on a section ¼in. by 1in. the figures would be 4000 lb. and 7500 lb. Points that enter into consideration are the resistance to corrosion and abrasion, which should be considerably higher than for ordinary steel, the possible unpleasant effect of noise due to vibration, the difficulty of getting a flat surface on large sheets, and the relation of the steel to such shop work as welding, punching, and hot and cold bending.

Geodesy and Geology.

In geological surveys under American Federal and State Governments there has been increasing use of geophysical methods in regular rather than experimental work. Electrical methods have been used in working out fault patterns, making marsh soundings, and studying quarry conditions. Earth' resistivity and potential drop-ratio methods were used in studies of iron ores and water resources, as well as in surveys of sand, gravel, and road material resources. Other surveys have mapped areas with the magnetometer in the search for structural features indicating oil and natural gas resources, and to determine the character and outline of glacial deposits. At some of the sites for large dams now proposed or under construction, the geological studies have been supplemented by geophysical methods, while the great droughts of 1934 have led to work which indicates that geological formations likely to produce artesian water may be discovered. Some seismograph stations are utilising quarry blasts in determining the distance registration of earth shocks or movements. A small electromagnetic instrument has been devised to locate small metallic masses near the surface of the ground. This is being used by some utility concerns in tracing the location of water and gas mains. In the oil fields, especially, the geophysical methods of prospecting are being used extensively. It appears that the oil industry in general has had in the field some ninety-five seismic crews, forty-five torsion balance crews, ten magnetometer crews, seven pendulum crews, and three gravimeter crews. Electrical coring methods are of great importance, but are not for primary prospecting, as they require the drilling of wells. In view of the fact that the new oil resources discovered do not equal the current consumption, it is inferred that there is a general depletion of reserve, and that in future there will be a much more extensive use of geophysical methods to bring in additional sources of oil supply. Under such conditions there are continual improvements in the instruments and appliances used for such surveys.

According to a report in *Shipbuilding and Shipping Record*, Russian authorities are negotiating with several Dutch shipping companies for the purchase of further tonnage. It is believed that the negotiations concern about twenty ships, including the whole fleet of the Netherland Lloyd, Rotterdam, namely, the "Dijkwater," "Galgewater," Leeghwater," "Minnewater," "Molenwater," "Oudewater," and "Zwartewater," laid up at present at Amsterdam and Rotterdam. Two tugs, the "Ham 408" and "Ham 409," have also been sold to Russia. These transactions bring the total purchases of shipping by the Soviet during the current year to thirty-three ships, aggregating about 88,000 tons gross, including some tugs. During the whole of 1934 Russian purchases of cargo tonnage amounted to thirty-five ships. Other reports say it is expected that an important stage in the development of the Russian mercantile marine will be reached in the near future by the inauguration of a Transatlantic passenger service from Leningrad to New York and possibly from the Black Sea to the Far East.

Rail and Road.

AT the recent annual meeting of the Dock and Harbour Authorities' Association complaint was made that at some of the railway-owned docks the revenue on the dock undertaking was not sufficient to cover the working and maintenance expenses, but the deficiency was made good by the other undertakings of the railway company. The privately owned docks were quite prepared to compete on equal terms, but it was unreasonable to expect them to compete with concerns carrying on their business with insufficient or no return, relying on other parts of their undertakings to make up the deficiency.

IN a leading article, "The Regeneration of British Railways," which appeared in THE ENGINEER of May 25th of last year, reference was made to an economy in permanent way operation that had originated on the Great Western Railway and which Mr. Carpmael, two years ago, anticipated could save British railways £400,000 a year. The system in question is the use of motor-operated platelayers' trolleys, which convey men and material quickly to and from their work. Very great advances have been made therein, particularly on the London and North-Eastern, in their size and speed, and now that company has provided the Glasgow district of the Scottish Area with a four-wheeled vehicle, with a roof and open sides, that will accommodate thirty-eight men and their equipment. It has an overall length of 19ft. 8in., a wheel base of 9ft., and can be driven from either end. Sanding gear, for both directions, is provided. The radiator is slung under the chassis. Under the official test a speed of 35 m.p.h. was attained on a measured mile.

VERY much satisfaction was experienced in railway circles, especially at the recent annual meetings of the stock holders, at the judgment of the Railway and Canal Commission, mentioned herein on February 17th, in the Southern Railway Rating Appeal against the assessment made by the Railway Assessment Authority. That amount was named as £2,180,000, but the Railway Commission reduced it to £1,077,131. When, however, on March 21st the Railway Assessment Authority came to consider the assessment of the London and North-Eastern Railway, Mr. Joshua Scholefield, K.C., the President of the Authority, stated that they were appealing to the House of Lords on the Southern Railway case. The L.N.E.R. representative thereupon asked for an adjournment. That was refused, but when the court met again on the 22nd, it was agreed to and the railway company promised that no trader should be prejudiced by the delay. The Authority had fixed the L. and N.E. assessment at £3,500,000; local authorities said it should be £5,000,000, but the railway thought it should be a nominal figure.

POPPLETON Junction, York, is the southern end of the colour-light signalling between York and Northallerton, L.N.E.R. At about one o'clock on the morning of August 6th last, the 7.45 p.m. express from Edinburgh to King's Cross was pulled up at the inner up home signal at Poppleton Junction, U.1, and that signal was immediately afterwards changed from "red" to "yellow" to allow the train to proceed forward to the advanced starting signal. At a point 961 yards behind the tail of the train was an automatic signal, U.2, which should have been at "red" to protect that train. The next signal was U.3, the outer up home signal, and 1264 yards from U.2. Signal U.3, it was agreed, was a "yellow" when the following 10.45 p.m. express from Newcastle approached and passed it. Both U.2 and U.1 became visible after passing signal U.3. Owing to a gentle left-handed curve that starts 474 yards on the York side of U.2 and which ends 60 yards beyond it U.1 appears to the left of U.2. A peculiarity about the single-unit colour-light signals is that their brilliance is such that their nearness is hard to judge and it may be assumed that when the driver of the second train saw U.2 at "red" and U.1 at "yellow" he mistook the order of the signals. After having mentally registered what he took to be their indications, he apparently allowed his attention to be relaxed and he ran by the "red" in U.2 and collided with the other train. As Colonel Woodhouse, who inquired into the accident, remarks in his report, that assumption would also account for his failure to notice the tail light of the train in front until too late to stop clear of it.

IT was thirty-five years ago on March 28th since a very serious collision occurred at Charing Cross Station, Glasgow, on the then North British Railway. Owing, it was alleged, to the Westinghouse brake failing, a passenger train came to a stand in the section to the rear of that signal-box. When the man in the next box in the rear had not received the out-of-section block signal for that train and wanted to send another he asked the Charing Cross man the reason. The latter assumed that the first train had passed, but that he had failed to intimate its passage. When, however, he wanted to send the train-out-of-section block signal he found that he could not do so. That was due to the line being protected by the Sykes lock-and-block system, and so it was not possible to actuate the block instrument suitably unless the train had arrived. The man, therefore, assumed that the system had failed and he used what is known as the releasing key in order to unlock his instrument and to send train-out-of-section for the train that had broken down and to accept the second and a collision followed, in which seven passengers were killed. The releasing key, as its name implies, is to release the instrument in case the signalman commences an operation which he does not complete—a train being shunted instead of going forward or a signal sent forward in error. The accident revealed a lack of discipline as to the maintenance of the block communication and to Sir Arthur Yorke observing in his report that he had no hesitation in saying that although the company had gone to the expense of supplying such a useful apparatus, which, if properly used, would render such an accident almost impossible, it had not received fair treatment or been employed in the manner prescribed by the rules. He also suggested that the use of the releasing key should be safeguarded so that access to it could not be obtained without the knowledge and consent of some person in authority other than the signalman.

Miscellanea.

THE London County Council has affixed a tablet to 24, Abingdon-street, Westminster, to commemorate the residence there of Thomas Telford, the engineer.

A FACTORY for the manufacture of cocoa butter from cocoa beans is to be erected at Hull. The cocoa beans are to be imported from West Africa.

AN establishment for the construction of all kinds of steel work is to be put up at False Creek, Vancouver, B.C., at a cost of 350,000 dollars, by the Western Bridge Company, Ltd. The company is a subsidiary of the Hamilton Bridge Company, Ontario.

AT the general monthly meeting of the members of the Royal Institution, held on April 1st, it was resolved to establish a Professorship of Astronomy. Sir James Jeans was nominated, and in the event of his election at the ballot on May 7th, will become the first Professor of Astronomy in the Institution.

TWO associated American firms, the U.S. Industrial Alcohol Company and the U.S. Industrial Chemical Company, have their plants built 1½ miles apart. It was decided that one boiler plant would economically supply steam for the two works, and a 12in. pipe line, 8368ft. long, carried on overhead steel structures and wooden posts, has been installed.

IT is understood that the Commercial Solvents Corporation is to acquire the disused oil refinery at Bromborough, and that work on the transformation of the refinery has actually commenced. Commercial Solvents Corporation have for many years been established as large suppliers of organic solvents in this country, but have hitherto had no factory here.

A NEW type of explosive with several advantages is described in the *Scientific American*. Known as Nitramon, this new material cannot be detonated by the standard commercial blasting cap, by impact, flame, or even by a rifle bullet being fired into it. In use it is exploded by means of a large diameter cartridge of dynamite and is rendered absolutely water resistant by being sealed up tightly in a tin can. It is stated to represent the ultimate in safety in so far as a blasting agent is concerned.

SOME 400 railway points at the new central railway station at Milan are kept clear of snow by electric heating elements. Near each of the points is fixed an electric heating element enclosed in a D-section copper sheath, the flat side of which is secured to the side of the rail by means of cams. During the winter of 1933–34 the installation was brought into operation over a period of 92½ hours, during which the amount of power used was 127 kWh, the heating elements melting snow from the points at the rate of about 35 mm. per hour.

CONSTRUCTION of bridges which will cost £143,000 will be begun shortly in Durban and the surrounding district. The first all-concrete railway bridge of its design in South Africa will be built at Amanzimtoti, at a cost of £17,000. The longest overhead road bridge in Natal, plans for which are now in preparation, will be built at the Congella shunting yards to replace level crossings and to carry road traffic over twenty railway tracks. This bridge will cost £50,000 and take two years to build. Other bridges will be erected at Umgababa (£17,000), Doonside (£12,000), and Argyle-road, Durban (£15,000).

A PROCESS has been patented for the silver, nickel, chrome, and electro-plating of china, glass, wood, rubber, moulded articles, &c. The article to be plated, after cleaning, is coated by an electrically conductive layer of metal powder, which has a lower potential than copper. Mixed in a suitable varnish, it is then immersed in an acid copper bath, which acts as a binding bath without the use of electric current. This galvanic coppering proceeds in the usual manner, *i.e.*, the article leaving the binding bath is placed in a galvanic acid copper bath in the manner usual in the manufacture of electrotype plates.

A NOTE in the *Chemical Trade Journal* says that the Ruhr mining companies, in conjunction with the Rhine Westphalian Coal Syndicate, have appointed an expert committee to study the question of the low-temperature carbonisation of Ruhr coals. The difficulty apparently is that of disposing of the semi-coke. It is hoped to find an outlet for this product as a generator fuel, but it is considered that satisfactory methods for removing the ash from the coke are first to be found. The committee will co-ordinate the research towards this object, and will also investigate proposals for the operation of low-temperature carbonisation plants in the Ruhr on a co-operative basis.

THE Automobile Association is introducing throughout the country a service to enable motorists to check the accuracy of their speedometers on the road. A fleet of cars with specially checked speedometers, in charge of A.A. officials, will operate on various unrestricted roads. The front and rear of each car will display notices inviting motorists to check their speeds against the A.A. speedometers. Ultimately every A.A. patrol's motor cycle combination will be similarly equipped to enable members to carry out periodical tests whilst on the road. The Association is also arranging to indicate by special notices at a number of important points on main roads a series of "measured miles" so that motorists can time their speeds for comparison against the reading of their speedometers.

THE service department of the Canadian Westinghouse Company has discovered one more practical use for a D.C. motor generator welding set. In pouring concrete in a large power-house some conduits became plugged, and since no one knew exactly where the pipes ran in the floors and walls, the problem was to locate them without digging up unnecessary parts of the flooring. By connecting the electrodes from the welding set to the ends of the pipes and using an ordinary compass, it was possible to draw a chalk line directly over the pipe in trouble. A fish tape was then used to measure the distance from the ends to the plugged portion, making it possible to break out the concrete directly at the point of obstruction. In spite of the fact that the pipes were 14in. below the surface, half an inch or less deviation from the direct line could be detected by the compass needle.

Air and Water.

A NEW aerodrome, owned by Provincial Airways, Ltd., has been opened at Denbury, about 6 miles north-west of Torquay.

THE Union-Castle liner "Saxon" has been sold for breaking up. She is a twin-screw vessel of 12,385 tons gross and was built in 1900.

IT is reported that two destroyers, each of 2200 tons, for the Polish Navy, are to be built by J. Samuel White and Co., Ltd., of Cowes, Isle of Wight.

ACCORDING to recent figures, leaking water taps detected in Glasgow houses cause a wastage of 15 million gallons of water a year, and it is estimated that the undetected loss would double this figure.

SIX new aerodrome sites have been chosen in Borneo for the projected air route between Singapore and Hong Kong *viâ* Borneo and the Philippines. The sites are at Kuching, Bintulu, Miri, Labuan, Jesselton, and Kudat.

IT is probable that the Wright aeroplane, now in the Science Museum, South Kensington, will be returned to America next year, to be exhibited in the museum of the Aviation Institution being formed at Kitty Hawk, North Carolina.

THE first successful night flight by a glider was recently made by Mr. C. Nicholson. The flight lasted 40 min. The glider is reported to have reached a considerable altitude and on several occasions was above the clouds. Communication with the ground was maintained by means of flashlight signals.

IN India, an Aviation Division of the Public Works Department has been formed under the charge of Mr. C. J. Rae, of the Engineering Service. Its object will be to undertake capital works in connection with the extension of the present aerodromes in Sind and at Ahmadabad, and their adaptation to flying in all weathers and at night.

THE six steamships which comprised the fleet of the Buenos Aires Great Southern Railway have been sold. Three of them, the "Salado" (5144 tons gross), "Segura" (5295 tons), and "Zapala" (4895 tons), have been sold to the Holder Line, Ltd., of London. The "Azul" (5287 tons gross), "Galvan" (5185 tons), and "Lomas" (5256 tons), have been bought by Kaye, Son and Co., Ltd., of London.

A NEW post in civil aviation, that of operational adviser to the Director of Civil Aviation, has been established, and to it Captain Ivor McClure has been appointed. He will be in charge of the inspection of aerodromes for licensing in Great Britain and the Empire and will deal with the operational side of civil aviation, working with the civil air lines in regard to technical requirements, developments, and the collection and preparation for issue of aerodrome and air route information.

UNDER the ægis of the Chamber of Shipping a special committee of coastal shipowners has been formed for the purpose of watching the interests of coastwise shipping under the Road and Rail Traffic Act, 1933. The committee will be known as the Coastwise Shipping Road Traffic Committee, and one of its chief functions will be to represent the joint interests of the coasting trade whenever applications which threaten unnecessary competition with coastal shipping are made to the licensing authorities set up under the Act.

A NEW fast type of machine, the Potez 62, is being put into service during the coming season by Air France. These machines have a gross weight of 15,765 lb., and an empty weight of 8800 lb. The engines are two Gnome-Rhone "Mistrel Major 14 Krsd" fourteen-cylinder two-row radials, giving 900 h.p. at 4920ft., fitted with N.A.C.A. cowlings, and driving three-bladed metal air screws. Each half of the undercarriage is of cantilever construction, and folds into the nacelles behind the engines. The machines have a cruising speed of 175 m.p.h., and a normal range of 625 miles, carrying fourteen passengers.

ACCORDING to the 1935 programme of the Portsmouth, Southsea, and Isle of Wight Aviation, Ltd., all services will be generally speeded up with the fleet of new Airspeed aircraft, comprising both Lynx Envoys and Lynx Couriers, shortly to be delivered. All these machines are being equipped with wireless, with Sperry artificial horizons and directional gyros, and with Reid and Sigrist turn and bank indicators. The Lynx Courier has a cruising speed of 140 m.p.h., and the Lynx Envoy has a cruising speed in excess of 155 m.p.h., with a maximum speed of over 175 m.p.h. The latter aircraft can also maintain height fully loaded with one engine out of action.

A NOTE in the *Far Eastern Review* states that a joint Japanese-Manchukuo airship service connecting Tokyo and Hsinking, later to be extended to Singapore and eventually to the United States, is to be inaugurated next spring by the National Aeronautical Policy Research Society. To start with the company, which will be known as the Pacific Airways Corporation, will use one Zeppelin of the "LZ 129" type, but eventually it expects to employ three airships. The first Zeppelin is to be purchased for six million yen, and it is reported that a representative of Dr. H. Eckener will arrive in Japan in November to negotiate the sale. The "LZ 129" type of dirigible has twice the capacity of the "Graf Zeppelin" and can carry five light aeroplanes.

ON Saturday, March 30th, on the arrival at Southampton of the North German liner "Europa," the Mayor of Southampton presented to Captain O. Scharf a pair of inscribed binoculars on behalf of the Clydesdale Navigation Company, Ltd., the owners of the ss. "Blairgowrie," which was lost with all hands in mid-Atlantic on February 20th. In accepting the gift, Captain Scharf said that his only regret was that the immediate efforts made by the "Europa" to reach the "Blairgowrie" were unavailing. The storm, it may be stated, was the most severe ever experienced by the liner, and the ship rolled about 36 deg., while the height of the waves was assessed at 16 m. The effect of the very high wind on the high superstructure of the liner rendered her navigation very difficult. Many passengers have since expressed their appreciation of the fine seamanship of Captain Scharf and his staff during a difficult voyage.

HYDRO-ELECTRIC POWER STATION AT CARDANO, ITALY

(For description see page 346)

FIG. 12 (ABOVE):—235-KV OUTDOOR TRANSFORMER STATION FOR INDUSTRIAL SUPPLY

FIG. 13 (BELOW):—GENERATOR ROOM: ALTERNATORS FOR RAILWAY SUPPLY IN FOREGROUND

FIG. 14 (ABOVE):—OUTDOOR TRANSFORMER STATION FOR RAILWAY SUPPLY

FIG. 15 (BELOW):—36,000-KVA TURBO-ALTERNATORS FOR INDUSTRIAL SUPPLY

The Engineer

APRIL 5, 1935.

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Contents.

THE ENGINEER, April 5th, 1935. PAGE

A SEVEN-DAY JOURNAL ... 345
HYDRO-ELECTRIC POWER PLANT AT CARDANO. No. II. (Illus.) 346
THE DEVELOPMENT OF PARSONS INDUSTRIAL TURBO-MACHINERY. No. XIII. (Illus.) ... 347
OBITUARY—J. G. H. Warren ... 350
THE TWENTY-FOUR-FOOT WIND TUNNEL AT FARNBOROUGH. No. I. (Illus.) ... 351
LETTERS TO THE EDITOR—
The Consumer—Standardised Worm Gears—High-Speed Trains—"Unempayment" and Engineers ... 353
THE BEND TEST AND ITS VALUE AS A GUIDE TO DUCTILITY. (Illus.) ... 354
AMERICAN ENGINEERING NEWS ... 356
RAIL AND ROAD—MISCELLANEA—AIR AND WATER ... 357
LEADING ARTICLES—
The Patriarch in the Factory—Security and Foreign Trade ... 359
DUCTILITY AND THE BEND TEST: INSTITUTION OF MECHANICAL ENGINEERS ... 360
LITERATURE—SHORT NOTICES—BOOKS RECEIVED ... 361
THE CENTRAL ELECTRICITY BOARD'S REPORT ... 362
THE FARADAY LECTURE ... 362
TESTS ON VOLTAGE REGULATORS. (Illus.) ... 362
ELECTRICAL EQUIPMENT AT THE NEW BARKING PUMPING STATION. (Illus.) ... 363
A PORTABLE COMPRESSOR. (Illus.) ... 363
AN IMPROVED OIL-PRESSURE GAUGE. (Illus.) ... 364
A PORTABLE DRAW-CUT SHAPER. (Illus.) ... 364
SIXTY YEARS AGO ... 364
THE ENGINEERS' GERMAN CIRCLE ... 364
BRITISH STANDARDS INSTITUTION ... 364
HIGH-PRESSURE MARINE BOILERS. (Illus.) ... 365
NEW YORK AEROPLANE LANDINGS ... 368
ARSENIC AS A WOOD PRESERVATIVE ... 368
CATALOGUES ... 368
LAUNCHES AND TRIAL TRIPS ... 368
MARKETS, NOTES AND NEWS ... 369
CURRENT PRICES FOR METALS AND FUELS ... 370
FRENCH ENGINEERING NOTES ... 371
BRITISH PATENT SPECIFICATIONS. (Illus.) ... 371
FORTHCOMING ENGAGEMENTS ... 372
THE INSTITUTION OF AUTOMOBILE ENGINEERS ... 372
PERSONAL AND BUSINESS ANNOUNCEMENTS ... 372
CONTRACTS AND ORDERS ... 372

NOTICES TO READERS.

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THE PATRIARCH IN THE FACTORY.

THE Order Book—or Minutes Book—of the New Wire Company, Cheadle, 1788–1831, of which the contents were summarised in a paper read before the Newcomen Society on March 27th, and reprinted in our last issue, forms a useful corrective to views, commonly held, about the employers in the early years of the industrial revival. "The evil that men do, lives after them," because it attracts attention, whilst the "good is oft interred with their bones," because, being normal, it is unobserved. A man may lead a life of complete respectability and even benevolence and never find his way into history. But let him in a moment of absent-mindedness leave a body in a canal or deposit it in a trunk at a railway cloak-room, and he becomes the "cynosure of all eyes." Thus there is always a danger, too often realised, that historians will see bad actions in sharper perspective than good. Good actions, like the introduction of Factory Acts, become the magnifying glasses of bad actions. Reformers, be they individuals or Royal Commissions, stress the defects of the thing they desire to correct, and pass lightly over its virtues. Thus the historian of factory life, depending as he does upon the reports of Commissions and the harrowing arguments of reformers has painted a picture of factory conditions in which gloomy passages and lurid lights prevail. Whilst it will not be denied that there was enough, and more than enough, justification for such canvasses, it is, we suggest, possibly unfair to regard them as representing general conditions. More often perhaps a picture in the calm style of a Dutch interior, or of some of the charming engravings of factories which may be found in collections, would truly represent the facts.

The Cheadle Order Book is a completely unvarnished tale. It is a record of the minutes passed by the partners at their meetings, and nothing more. Its very baldness and simplicity adds to its value as an historical document. The clerks or secretaries who wrote the minutes had no reason to suppose that they would ever become of historical importance, or that the public eye would ever fall upon them. No *arrières pensées* fluttered their minds whilst they were writing them. They never suspected that their pages would reveal to a future generation what manner of men were to be found amongst employers in the most calumniated years of industrial progress. It was suggested at the Newcomen meeting that country works like those at Cheadle were better than city works; that the "patriarchal" atmosphere could be found on the banks of the Churnet and be wanting on the Don in Hallamshire. In a measure that may have been so. But we find it hard to believe that the city employer had a different heart from the country employer. The brutalising conditions which were often to be found in industrial cities were not there because all employers were bad men, but because the circumstances of the congested life in factory areas was deplorable for reasons over which the employer had no more control than any other citizen. If the minutes books of city firms some day come to light, we shall be surprised if they do not show that the partners were just as patriarchal, in will at least, as those of the New Wire Company. It is, indeed, certain that the little family epic of the Brindleys of Cheadle, might be repeated in a hundred cities, just as similar epics may be found in scores of works at this day. The Brindleys—grandfather, father, and son—were a troublesome trio. They provoked the partners by laxity in their duties and by obstinacy, but their delinquences were tolerated with astonishing patience. On one occasion the partners were moved to reprimand the father, Matthew, in good round terms. But before the ink was dry upon the paper of the minutes book, their anger had evaporated, and their severe scolding changed into an earnest admonition tempered by an increase in salary! But that was the way of the partners, not alone with the Brindleys, to whom they must have had a particular attachment, but with all their men. Over and over again we find records of gifts or of arrangements made for the convenience of the men. In one case, perhaps the first in history, they sent a young man up to London at their charges to be educated in Chymistry. That young man subsequently became a successful employer himself. Yet with all their kindness the partners could be firm enough when matters affecting the honour and reputation of the company arose. Witness their very strong minute in 1810 when they had to deal with "very general complaints (which the Co. views with great regret and indignation)," that the wire is irregularly drawn. They were not weak men, and the reputation their products enjoyed shows that they were capable men of business. But they combined with their other qualities the "patriarchal" spirit in their dealings with their men.

Can such things be at the present day and under modern conditions? We firmly believe that they can—in certain circumstances. There may still be found firms in which the workers are all personal friends of the employers, and in which every individual, from the meanest boy "on the floor" has a personal attachment for the concern. But the growth of factories and trades unionism has done much to undermine it. The "growth," for obvious reasons; "trades unionism" because it replaces the individual by the mass. No employer is unaware of the merits of the personal touch and those that are wise are at some pains to maintain it, even against heavy odds. But in the largest firms it is but the ghost of what it was. The "patriarch" himself has been replaced by a seneschal, and individual kindness has become an organisation. An incalculable amount of good has been done by the welfare system, and in the circumstances no alternative is possible; but it does not remove the disadvantage that in great companies the men even in higher positions may become mere units of no individual interest to the management. Since the personal attachment of its servants is an invaluable asset to any firm, an expansion of the direct interest of the employer in the happiness and progress of those who work for him would add to the contentment and devotion of many a young man and benefit the business at the same time. That it is not more common is in part due to the men themselves, some of whom regard friendliness as interference, and accordingly resent it. If they will not meet the employer halfway, his course becomes so hard that he has every justification for giving it up altogether.

Security and Foreign Trade.

A BRITISH appeal to the French nation for a clear judgment upon the real causes of the world's economic disorder has been made through the Paris journal *Le Temps* on March 30th by twelve representatives of industry, politics, and finance, headed by the Marquis of Crewe, former ambassador in Paris. The signatories include Lord Essendon, Lord Farrer, Lord Gladstone, Sir Richard D. Holt, Lord Rhayader, President of the Cobden Club, and Liberal and Labour ex-Ministers. It is a plea for the suppression of State control of industry and trade, and a return to the economic law of supply and demand, which, in the words of the appeal, "can alone ultimately fix the limits of production, the needs of consumers, price levels, and the conditions under which traders will be able to carry on business successfully and labour find normal employment." The appeal is made at a time when the French have ample food for reflection after the devaluation of the belga and the failure of Governments to raise the fortunes of industry by methods that have complicated an already involved situation. Each attempt to correct past errors has made matters worse. All industrial and commercial communities are suspicious of State initiative, though turning to the State in their helplessness, and then scrutinising every Government project in order to ensure that the State shall not arrogate to itself powers of independent and permanent control. When the President of the Council, Monsieur Flandin, declared that the Government's policy would be a gradual return to liberty, and that control would only be exercised during periods of crisis, there appeared to be better hope for the future. With a view to deflating prices, economies were effected in national expenditure, and all classes of manufacturers sought safety in a retrenchment of production costs. Wages could only be cut by lowering the cost of commodities, which necessarily reacted on agriculture. Nearly one-half of the entire French population lives on agriculture, and farmers rose in a body against the Government, because of its failure to ensure for them remunerative prices, and boycotted the products of manufacturing industries on the plea that the interests of the agricultural community were being sacrificed to those of industrialists. No one will admit that a way can be found out of the difficulty, except by a professional control of production, in collaboration with the State.

The experience of France since the war has been the same as that of other Continental countries. The rise of economic nationalism is based upon a desire for security. There must be as little dependence as possible upon foreign supplies of raw material and produce, and manufacturing industries must be developed to provide everything that may be required in times of emergency. The phenomenal activity in extending a specialised production of material during the war by increasing existing plants and building new factories and encouraging neutrals to install works in France for the manufacture of essential machines, was necessarily followed, after the Armistice, by measures to ensure a continuance of those industries. The importance of national shipping gave an impetus to the extension of shipyards and the creation of new ones. Factories and shipyards were largely equipped with the aid of reparations from the vanquished country. The need for raw material initiated a policy of colonial development with the idea that African territories between the Mediterranean and the Equator would supply everything for the country's requirements. In the same way, agricultural production was organised under State supervision. All native sources of energy were utilised by a reorganisation of the colliery industry and the construction of hydro-electric power stations. This policy of economic nationalism, in France as in other countries, had the result of upsetting the balance of supply and demand. There was far too great a production of some goods and an insufficient supply of others, and as fiscal barriers had to be raised for the protection of industries that were primarily intended for national defence, foreign markets were restricted, and finally closed to exporting industries. In these circumstances, it is obvious that a policy of foreign trade exchanges is necessarily influenced by the organisation of national defence, which records the capacity and utility of works and factories throughout the country, and is ready to mobilise them at short notice. It explains changes of French attitude in matters of foreign commercial policy, alternating between liberalism and restriction, according to the international outlook and maintaining a reserve in negotiations that are likely to affect the national production.

This development of industry as an aid to security was undertaken on the assumption that it would constitute a factor in national prosperity. It cannot be judged yet to what extent that expectation will be realised. Currency problems, which are themselves a product of economic nationalism, have not enabled industry to give a

measure of its power to contribute to the country's wealth. Some industries suffer drawbacks through labour shortage in normal times, and their geographical position with respect to the supply of raw material, and it is difficult to see how they can be maintained without protection from foreign manufacturers who can sell similar products more cheaply. These inconveniences are now recognised in France, and in normal circumstances there would be a withdrawal of artificial support from such industries, if there were no alternative, as a means of enabling exporting industries to regain their foreign markets. For the moment, the situation is too involved to be easily unravelled. No start can be made without currency stabilisation, and that would give rise to difficulties in adjusting values to an international standard. Even that adjustment might not bring about a full recovery of international trade until there was an assurance of security in the future. Moreover, the prospect of a return to the old order of things is remote. The partial disappearance of invisible exports has given so much importance to the balance of trade in France that reciprocal trading will continue to form the basis of commercial agreements with other countries. The British plea for freer commercial exchanges is, nevertheless, fully appreciated in France, where, unfortunately, the idea of its acceptance as a solution of present difficulties is obscured by the political outlook. A carefully protected industrial production that limits the possibilities of foreign exchanges is regarded as so essential to national security that there is little hope of a wide development of trade with other countries until the general feeling of insecurity is removed.

Ductility and the Bend Test.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE paper entitled "The Bend Test and its Value as a Guide to Ductility," which Mr. L. W. Schuster, technical adviser to the British Engine Boiler and Electrical Insurance Company, Ltd., presented before the Institution of Mechanical Engineers on Friday evening of last week, March 29th, contained a large amount of interesting and valuable information, but its exceptional length—it will occupy a hundred pages of the "Proceedings"—clearly told against its satisfactory discussion. Not all the speakers, obviously, had prepared themselves by studying it thoroughly beforehand—a fact for which little blame need be attached to them—and in what they said there was, perhaps naturally, a considerable amount of repetition.

Dr. G. A. Hankins opened the discussion. He held that Mr. Schuster's subject was of real importance, because bend tests were included in nearly every specification for ductile materials. In the first few pages the paper established a new result, namely, the relationship between the ductility shown by a bend test and that exhibited in a tensile test. It then proceeded to discuss the effect of width in bend test specimens. That effect had been known for many years. For example, fifty years ago Sir Benjamin Baker in a paper before the Institution of Civil Engineers had remarked upon the fact that it was much easier to bend a narrow specimen than a wide one and argued that as a consequence the width of specimens to be subjected to bend tests should be specified. The author's diagram showing the relationship between lateral contractions of bend test specimens of different width—reproduced in our abstract of the paper as Fig. 1—was, Dr. Hankins thought, very important. It was based on the results of many laborious experiments, but it should be noted that it applied to mild steel and was not necessarily applicable to other materials which would probably give other forms of diagram. Discussing bend tests on butt-welded specimens, he said that the value of that form of test had been widely recognised particularly in the United States and that a bend test for such specimens had now been adopted by the National Physical Laboratory. Why, he asked in conclusion, were so many bend tests carried out on other than welded metal? The obvious reason was because such tests were prescribed in the specification. Was there however any positive evidence that bend tests revealed properties other than those brought out by tensile tests? He thought that some information concerning bend tests in which the specimen had failed would be of general interest.

Dr. L. Reeve said that at the Scunthorpe Works something like 10,000 tensile tests and a vast number of bend tests were carried out every month. Mr. Schuster had, he thought, managed to clear up some of the discrepancies and inconsistencies occasionally encountered in the conduct of bend tests. He had succeeded in introducing a considerable amount of law and order into the subject, as for example in connection with the effect of width and length of the specimen. Perhaps the most important result given in the paper was the correlation of the elongation in a bend test with the reduction of area in an ordinary tensile test. The masterly manner in which Mr. Schuster had carried out his investigation made it almost unfair to criticise the paper. Nevertheless it might be said that his original thesis, in which it seemed to be suggested that in some way a bend test was superior to an ordinary tensile test, had not been established. Mr. Schuster had certainly made it clear that the bend test was of very great importance in the examination of butt welds, but he, Dr. Reeve, did not think that the ordinary tensile test, with, if necessary, a measurement of the reduction of area of the specimen, was likely soon to be displaced. He did not think that Mr. Schuster had shown that the bend test possessed any particular advantage over a tensile test. It was true that with care the bend test would give all the information obtainable from a tensile test, but what else did it give? No doubt one advantage that might be claimed for it was that it could be carried out in a workshop by means of a vice and a hammer, but that process of conducting the test had been shown by Mr. Schuster to be open to criticism and to be generally untrustworthy. He would like the author to state whether he preferred the A.S.M.E. bend test to the ordinary bend test conducted with a plunger and former. He thought it might be necessary in the A.S.M.E. test to specify exactly the manner in which the initial 30 deg. bends at the end of the specimen were to be made.

Sir John E. Thornycroft discussing the advantages of the bend test over tensile tests mentioned an instance within his own experience in which certain forgings which had passed the Government tensile test had failed under a bend test. Investigation showed that the hammer used in making the forgings had not been sufficiently large for the size of the billets. The material was good but had been spoilt in the forging process. The bend test alone was capable of disclosing the defect.

Professor F. C. Lea remarked that in many manufacturing methods processes were involved which called for the cold bending of the material. Again in a number of structures, such as riveted parts, there was a redistribution of unequal stress when the structure was loaded for the first time. The ability of the material to behave satisfactorily under either of these headings was revealed by a bend test, but he was doubtful about what other advantages such a test possessed. Continuing, he asked the author to define more clearly what he meant by nickel chromium steel. There were many varieties of such steel and it was important to know to which kind the author's results related. He asked Mr. Schuster to state whether his results could be used to shed any light on the behaviour of nickel chromium steels when notched, as for example by a screw thread, and subjected to a blow. At Sheffield it had been found that some nickel chromium steels which bent easily in a vice or gave good results in a bend-testing machine failed badly when notched and subjected to a blow. Again some nickel chromium steels gave very good results in a tensile testing machine, but if heat treated in a particular way and notched they might be very unsatisfactory.

Dr. A. F. Burstall disagreed with Mr. Schuster on several points, notably in connection with the diagram reproduced as Fig. 2 in our abstract of the paper. He asked whether that diagram really enabled us to deduce from the reduction of area in a tensile test what we would get in a bend test. He suggested that the experimental evidence on which that diagram was based covered only a limited range. He quoted the results obtained by other investigators which did not support the author's conclusions. In particular he mentioned a statement made by Jennings before the American Welding Society to the effect that the bend test did not measure the elongation revealed by a tensile test.

Mr. I. J. Gerard, of the Royal Aircraft Establishment, South Farnborough, remarked that the saturation point of the elongation in a bend test was reached long before the specimen was bent to 180 deg. Above a certain angle of bend farther bending merely extended the area over which the maximum elongation occurred. Lack of standardisation of the test conditions seemed to be a fundamental cause of trouble in connection with bend tests. He suggested that as a basis of standardisation the specimen should have a width equal to five times its thickness and a length equal to four times the diameter of the plunger used to produce the bending over a former with a 90 deg. vee notch. He asked the author to say whether the test could be carried out by hammer blows rather than by the application of slow pressure to the plunger. In aircraft manufacture much of the material used was in the form of thin sheets or wire of small diameter. In testing such material reliance had to be placed on bend tests because of the difficulty of measuring the reduction of area exhibited by the material under a tensile test.

Mr. J. Deschamps, discussing the use of bend tests on steel castings, said that such tests gave no indication of the ability of the castings to resist shocks. Would it be possible to devise a notched bend test which would combine the Izod test with the static bend test?

Mr. A. F. Webber, of the British Iron and Steel Federation, dealt with the question which had been asked, "Why are bend tests made?" The answer was, he said, that in the works the bend test was a rough-and-ready proof test. It was carried out much more frequently than tensile testing and was used to ensure that all specimens from one cast were up to the standard revealed by a tensile test. The British Standards Institution had now laid it down that one bend test was to be conducted on every 5 tons of material produced. If the bend test was to be transformed into a highly scientific procedure like a tensile test it would be impossible to keep pace with the output of the mills and it would be necessary to reduce the large number of bend tests now demanded. Great difficulty would also be caused by the introduction of a fixed ratio of the width to the thickness of bend test specimens. For the sake of practical convenience and speed of working bend test specimens cut from plates of different thickness were at present made with one standard width.

Mr. J. G. Pearce, of the British Cast Iron Association, said that in 1928 Mr. William Taylor had drawn attention to the great amount of information available concerning the properties of materials inside the elastic range—that was to say of information valuable to designers—and to the very small amount available concerning the plastic range—that was to say of information of value to manipulators of the material. Mr. Schuster's paper, he thought, would help to remedy that deficiency. He agreed with Mr. Webber that rapid commercial bend testing demanded a constant width of specimen irrespective of the thickness, but he pointed out that it was quite practicable to vary the diameter of the plunger in order to secure comparable results. The more precise the bend test was made the greater would have to be the allowances for factors which might lead to the rejection of the material.

Mr. W. H. Evans held that the bend test was useful and illustrated its value by reference to work done on behalf of the Safety in Mines Research Board. He illustrated on the screen a form of jig by means of which a bend test could be conducted in an ordinary compression testing machine. The feature of the device was its formation with three faces at 135 deg. to each other each of which in turn was placed on the platten of the testing machine. The specimen was given an initial bend and was thereafter bent to the final extent in three stages.

Mr. R. H. Stanger said that Mr. Schuster seemed to suggest that the bend test should be made really scientific. The measurement of the extension on the extrados could not, however, be made either easily or quickly and he did not think there was the slightest chance of the steel works being induced to give it. There was no purpose to be served, he argued, in making the bend test as scientific as it no doubt might be made. As an example of the discrepancies which might arise in the conduct of bend tests he said that he had found that if certain specimens of manganese bronze were tested tediously slowly they would fulfil the requirements of the specification but if the speed of testing was increased they failed.

Dr. S. F. Dorey asked why it should be necessary to apply highly scientific principles to a test which had hitherto been no more than a practical and visual demonstration of ductility. Bend tests should be included in a specification on the same basis as drop tests or crushing tests, which were demonstrations rather than evaluations of particular properties. Manufacturers who wished to satisfy bend test specifications which did not prescribe the methods of bending might with great advantage to themselves study Mr. Schuster's paper in order to discover the least severe method of obtaining the required bend. For the purpose of testing welded material the bend test possessed distinct advantages and such a test was now specified by Lloyd's for fusion-welded pressure vessels.

Mr. Schuster, replying to the discussion, said that it had been suggested that he regarded the bend test as in some way superior to a tensile test. He certainly did not. If all the information required concerning the elongation of the material could be obtained from a tensile test there was no need to carry out a bend test. Bend tests were very valuable as running workshop tests and also as applied to strip material from which round specimens could not be produced. They were also useful as a means of revealing surface defects. But he believed that to-day bend tests were often called for unnecessarily. Replying to Dr. Burstall, he said that the diagram Fig. 2 applied to a large range of commercial steels but that caution was required in applying it to special steels and other materials. He agreed with Mr. Deschamps that the bend test could not disclose the resistance to shock possessed by a specimen. Mr. Pearce, he said, was too modest to tell the meeting that he was chairman of the B.S.I. Committee appointed to investigate the standardisation of bend

tests, for which Committee the work described in the paper had been done. Mr. Evans' machine was very interesting but he did not like the application of the load at the end of the specimen. The results of the test would not be comparable with those of other investigators.

Literature.

Marketing Industrial Equipment. By BERNARD LESTER. Published by the London McGraw Hill Book Company. 1935. Price 21s.

A COMPREHENSIVE book on the marketing of industrial equipment has long been wanted. The reviewer knows only one book published by a British author which deals, however sketchily, with this important aspect of selling practice. The present work is American in origin, and while its range is wide, it suffers, perhaps, from the fact that its author is here not so much a sales manager or director dealing at first hand with the marketing of the type of equipment concerned, as an engineer attached to a university. The expert in marketing, seeking for those little practical selling hints that will solve for him the immediate problems of his work, will not always find what he is looking for. On the other hand, there is no doubt whatever that this book will clarify his ideas on a great many points, and enable him to work out for himself a line of attack as a result of its suggestive influence.

Mr. Lester is assistant sales manager of the industrial department of the Westinghouse Electric and Manufacturing Company of America—undoubtedly an impressive choice as the author of a graduate course for students of marketing capital goods, which this work represents. Nevertheless, in a way, his very impressiveness is a handicap, for obviously he cannot be expected in a highly competitive world to give away the intimate secrets of his successful salesmanship, and it is these intimate secrets for which every sales expert looks in a work of this character.

Primarily intended for students, therefore, Mr. Lester's book will be found in every way admirable as an exposition of the basic principles of industrial marketing. The opening chapter on the "Development of Industry" outlines the growth and change of industrial manufacture as a preliminary to discussing the stages in establishing a new product. It is typical, perhaps, of the American approach to the subject that on page 12 the author stresses the need to concentrate on selling the standard product wherever this is possible. The survey of trends in the functioning of engineering is sound and concise, but the note on business failures and management with which the chapter concludes is primarily concerned with the United States.

The scheme of the book is, first, to outline the character and extent of the industrial market; then to indicate the production machinery and equipment required by industry. An analysis is made of products, markets, competitors, and distribution. Factors in distribution and sales expense are next treated, and this section is followed by a thorough examination of the various departments of sales organisation, ranging from the formulation of a consistent and sound commercial policy to the complete carrying out of a market analysis. The chapter on sales promotion is disappointing. Much more could have been written on this subject, which is one of the least exhaustively dealt with of all the factors in marketing. With the author's separation of advertising and publicity into two water-tight compartments, it is impossible to agree. This is over-simplification.

The author makes a technical slip on page 87, where he refers to "cutting tools of high-carbon steel capable of operating at much higher speeds than common tools," as being perfected a few years ago. The reference is surely to the newer cobalt high-speed steels, which long ago supplanted the carbon steel.

The author's method of illustrating his points by actual "cases" has much to commend it. His book is a model of concise statement, even if the English is not without flaw, and the able way in which the text is arranged, combined with the excellent list of references and the index (which might, however, have been more detailed), make it eminently readable and of service.

Factory Administration in Practice. By W. J. HISCOX. Second edition, by JOHN R. PRICE, A.C.A., A.C.W.A. London: Sir Isaac Pitman and Sons, Ltd. Pages, 274. Price 8s. 6d. net.

IN perusing this book the first impression is the great stress laid upon the value of a progress manager in factory administration, and certainly the author has made a good case for this official. We are of opinion that when a new function is introduced its success or failure is largely dependent upon the status of the head of this department, and accordingly the author would be well advised categorically to define this, illustrating it by a "family tree" from the managing director downwards, clearly showing by the horizontal position the relative degree of responsibility vested in each individual.

As the author rightly affirms, "enthusiasm is essential to the well-being and success of administration," and this can only be ensured by assigning definite duties and also allowing the power to enforce the responsibility given.

The first edition remains virtually unaltered and is now comprised in Part I, in which the main functions of a modern factory are succinctly described in a manner eminently suited to the needs of students. In the concluding chapter Mr. Hiscox somewhat astutely disarms criticism by stating that "as the reader approaches the end of this part many omissions will no doubt occur to him." We agree and turn expectantly to Part II to ascertain how they are made good by Mr. Price, who now takes up the theme.

We confess to a measure of surprise on finding that he begins with a dissertation on factory buildings, which by no stretch of imagination could be considered part of "Factory Administration," but we notice that this chapter is inserted so that the syllabus of the examinations of the Institute of Cost and Works Accountants may be more fully covered. For a similar reason a chapter is included on "Power and the Machine," dealing in an elementary manner with a very wide subject.

In the next chapter on materials organisation we have a useful addition, and the principles of storekeeping and the lay-out of stores are very helpfully described, while in the last chapter, which is concerned with methods of control, we are glad to observe that the judicious use of charts and diagrams is advocated. There is no better way of keeping executives alive to their responsibilities and at the same time interested in the results of their activities. The brief illustrated description of the different charts suggested is excellent.

An appendix contains a considerable number of examination questions that have actually been set, and in scanning them we appreciate that anyone who has carefully studied the book under review will be in a favourable position to answer them; at the same time, we realise why apparently extraneous matter has been incorporated in a treatise on "Factory Administration in Practice."

We cannot let such statements as "the system of costing does not interest the man in the factory" pass unchallenged, for we are convinced that the modern engineer highly values the work of the cost accountant, and realises that he can obtain invaluable assistance from his colleague, and it is only when he fully understands the "system of costing" installed that he can ensure the maximum return from it.

Unless the estimating department—a section which is all too sketchily handled—works in the very closest co-operation with the costing section, and is under the control of an engineer who knows the worth of accurate costing, it is useless to expect the best results. In the highly laudable object of writing a book "from the factory standpoint," perhaps too little attention has been devoted to the other side.

The *personnel* department is so essential to the modern industrial establishment and its smooth running has so important a bearing on the general efficiency of the concern that we cannot understand why it has been passed over in silence.

Water Power: Its Estimation and Development, with Particular Reference to India. By J. W. MEARES, C.I.E. Calcutta: Thacker, Spink and Co. (1933), Ltd. 1935. Pp. 196, Figs. 12, Tables 14. Price 12s.

THE author, who was formerly electrical adviser to the Government of India and Chief Engineer, Hydro-electric Survey of India, has visited large numbers of hydro-electric plants in Canada, the United States, Norway, Sweden, Switzerland, and Germany. He deals with the elements of the subject in respect of economics, definitions, the classification of water power, calculation and measurement of discharge, the rating of rivers for power, and storage. Chapters are devoted to climate and water; reconnaissance and survey; headworks, canals, forebays, and tail-races. More than a third of the book is taken up by the last three chapters, on pipes and surge chambers; hydraulic turbines, and power stations; typical examples of lay-out, classified as for low, medium, and high falls. The author, whose command of simple language is as refreshing as it is rare, succeeds in conveying, throughout the book, clear ideas as to the relations of the inherent character and main features of a plant and its associated works to, on the one hand, the essentials of design, and, on the other hand, the incidentals of working the plant. His ability in that respect is especially evident in those last three chapters. In view of the success with which low falls on canals have been utilised in India, and of the significance of that success in respect of the many countries or regions in which, owing to the lack or paucity of high or medium falls, water power is not developed, the work is a timely one on a subject of major economic and engineering importance. While a large volume would be necessary for a full exposition, including mechanical and electrical technology and data, Mr. Meares has succeeded in presenting the subject in a small book which is at once an elementary text-book and a presentation of principles and practice such as will greatly interest consulting engineers and public works officers.

SHORT NOTICES.

Electricity Law and Practice. By R. H. Studholme, M.A. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 30s. net.—The extension in the use of electricity during the past few years has introduced a large amount of legislation of unusual complexity, and this book is intended to be a guide to legal practitioners and others connected with electrical undertakings to whom a certain amount of legal knowledge is necessary. The book owes its origin to notes made by the author whilst practising as a solicitor to electricity undertakers, and contains accounts of the most recent legislation and principal cases on the subject, with notes and comments of practical value. It includes the full text of all the Electricity (Supply) Acts, 1882–1935, of the Electric Lighting (Clauses) Act, 1899, and certain incorporated Acts with amendments to date; also the Commissioners' Electricity Supply Regulations, 1934. Wayleave problems, the obligation to supply, charges, and tariffs, departmental and legal procedure, and criminal offences are dealt with, and there is an appendix explaining the modification of the statutes in their application to Scotland. Among the other useful features are alphabetical lists of statutory definitions and penalties and protective clauses relating to gas, water, railway, canal, and other undertakings. The volume is completed with a comprehensive index, which enables the reader to trace easily any particular subject or point of interest. We feel sure that the book will be of practical value to local government officials, supply companies, members of the legal profession, and all connected with the supply of electricity.

The Superheterodyne Receiver: Its Development, Theory, and Modern Practice. By Alfred T. Witts, A.M.I.E.E. London: Sir Isaac Pitman and Sons, Ltd. 1935. Price 3s. 6d.—It is only within the last few years that the "super-het" has become a practical proposition for the ordinary licence holder. Most of us played with the circuit years ago, but its defects outweighed its merits and straight sets gained complete ascendency in this country. Then came the increase of high-power stations, the desire for long reach, and the necessity for high selectivity to cut out unwanted stations and "mush." The super-het could meet these requirements, and inventors took it up again, with the result that now the type is almost as common amongst multiple-valve sets as the direct type. The principle of the heterodyne receiver is fundamentally simple and is familiar to all who take an interest in wireless. But the accretions and modifications are not generally understood, and in this little volume the author has set himself the task of explaining them. He has made a good job of it, and whilst his book will not appeal to the amateur who only desires practical tips for the making of his own super-het, it will be welcomed by those who desire to understand the principles and practical elements involved in modern developments.

Stratosphere and Rocket Flight. By C. G. Philp. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 3s. 6d. net.—During recent years there has been a considerable revival of interest in the rocket method of propulsion, and this book deals in a non-scientific way with the subject. It opens with an interesting historical survey; the author then deals with the first principles of propulsion, speed, and space, and discusses the stratosphere and limitations of aeroplane flight. A short chapter on fuel, and the great problem of rocket propulsion, is followed by a discourse on atomic energy and its possible adaptation as a motive force if ever realised. Reaction motors are dealt with and the practical application of rockets for propelling automobiles and mail-carrying projectiles is discussed. The book concludes with chapters dealing with the use of rockets in warfare, imaginary long-distance flights, and interplanetary flights. Whilst interesting in a general way, the volume gives little information of practical importance. The future of rocket flight is, in the opinion of the author, however, within the bounds of possibility, and this is probably the first of a series of volumes which will deal with the scientific aspect of a new method of propulsion.—Astronautics.

BOOKS RECEIVED.

Specifications for Building Works. By W. L. Evershed, F.S.I. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 5s. net.

Common Features of Fire Hazard. By J. J. Williamson, F.C.I.I. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 6s. net.

Definitions and Formulæ for Students: Radio Engineering. By A. T. Starr, M.A. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 6d. net.

Standard Tables and Formulæ for Setting out Road Spirals. By A. Thom, Ph.D. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C. 2. Price 2s. 6d. net.

Structural Geology, with Special Reference to Economic Deposits. By B. Stoces and C. H. White. London: Macmillan and Co., Ltd., St. Martin's-street, W.C. Price 25s. net.

The Elements of Motor Vehicle Design. Second edition. By C. T. B. Donkin, A.C.G.I. London: Oxford University Press, Amen House, Warwick-square, E.C.4. Price 12s. 6d. net.

An Introduction to Structural Theory and Design. Second edition. By H. Sutherland and H. L. Bowman. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 17s. 6d. net.

Crushers for Stone and Ore: Their Development, Characteristics and Capabilities. By W. T. W. Miller, M. Inst. C.E. London: Mining Publications, Ltd., 724, Salisbury House, London Wall, E.C.2. Price 15s. net.

Modalita di Collando della ghisa grigia in getti (The Testing and Acceptance of Grey Cast Iron in Castings). By Dott Ing. Attilio Steccanella. Florence: Material and Traction Section, Italian State Railways, Ministry of Communications.

The Central Electricity Board's Report.

Now that the grid as originally planned has been completed some little time, the Electricity Board's reports are beginning to differ from those that were issued during the constructional stage. Accounts of engineering progress are giving place to a large extent to particulars of operation and trading, which, after all, are the points which appeal mainly to those associated with the electricity supply business. The seventh annual report, issued on Wednesday, April 3rd, shows that during the year 1934 the Board achieved a credit balance on general trading account of £86,101, while the saving in capital investment in generating plant up to the end of the year, and arising as a direct result of the grid, is estimated to have exceeded £9,000,000. As a result of the group working of selected stations, there were substantial economies in the consumption of fuel.

The Board's transactions during 1934 covered the second year's general trading under the grid tariff in Central Scotland and Mid-East England, where the tariff was introduced on January 1st, 1933, the first year's general trading in South-East and East England, and North-West England and North Wales, where the tariff was adopted on January 1st, 1934; also nine months' general trading in Central England, which came under the grid tariff on April 1st, 1934. General trading in South-West England and South Wales began on January 1st, 1935. The consumption of electricity in all the areas in which general trading was in progress during the year exceeded the estimates adopted by the Board in framing its budget, although the exceptionally mild weather in December reacted seriously upon the maximum demands of authorised undertakers on the grid. But for those abnormal conditions the credit balance mentioned at the outset would have been considerably greater.

Economies arising from interconnection depend upon the growth of demand, and it follows that the net saving available to selected station owners in the earlier years of the Board's trading are inevitably small. Experience has also indicated that the operation of Section 7 of the 1926 Act results in a distribution of those savings in a manner disproportionate to the service rendered to the scheme by each individual selected station owner. The Board has, however, discussed with its consultative Technical Committee for North-West England and North Wales a proposal for a more equitable distribution of the savings arising from group working as part of the grid system, while, at the same time, safeguarding the grid finances. The proposal which has been approved by the National Consultative Committee is now before the individual selected station owners. Further discussions on the problem are taking place between the Board and the National Committee with a view to making arrangements of this nature applicable to selected station owners in other areas.

Stress is laid on the fact that the first effect of the grid was to make a large proportion of the generating plant which hitherto had to be held in reserve revenue-earning. New generating plant, installed during the past five years, has consequently been of less capacity than would have been needed under the old scheme to deal with the 50 per cent. increase in electrical consumption that has been experienced in that period. As we have said, it is estimated that up to the end of 1934 the saving in capital investment on this score is estimated to have exceeded £9,000,000. As the difference between the capacity of spare plant required under grid conditions and under the old system increases with the growth of load, this saving will also continue to grow. Economies in fuel consumption are revealed by the fact that at the selected stations which were operating under independent conditions in 1932 and under the Board's direction in 1934, the average consumption of fuel in the latter year was less by over 7 per cent. than that in 1932, representing a direct saving approaching £500,000 in the operating costs.

As the result of the attention given to the elimination of the troubles inevitably associated with the introduction of an extensive electric supply system, the standard of security of supply is claimed to have been raised to a high level, and the unfortunate failure which occurred on Sunday, July 29th, is not expected to be repeated. It will be remembered that whilst certain grid lines were out of service, the South-East England system was deprived simultaneously of the export from two of the three largest stations in the area. While even on Sunday loading there has been a sufficient margin of generating plant in operation to compensate for the largest station's output, and sufficient spare plant ready to take up the load in the unlikely event of a second station failing, it was not thought possible that two major stations would ever drop out of service at the same time. Although the exceptional combination of circumstances on that Sunday morning is not likely to re-occur, the Board has made arrangements which will ensure that even if there should be an indication of similar circumstances arising, there need be no apprehension of any such general dislocation in future.

Since the advent of the grid, the Report goes on to state, there has been a tendency in certain quarters to attribute to it all interruptions in the public supply of electricity, although the greater proportion of them has been attributable to causes which have no possible connection with the grid. It is contended that against such interruptions that have arisen from the operation of the grid in its initial stages must be set the many cases in which dislocation of the supply has been avoided by its assistance. It would be interesting to know, however, whether the word "grid" used in this connection merely applied to the primary lines or to the secondary lines as well. Judging from reports and the efforts that are being made to overcome certain transmission line troubles, many of the failures within recent times have been due to transmission and other outdoor equipment associated with the national scheme. According to the Report, the electricity supply industry has always realised that there were two major difficulties to be overcome in connection with overhead transmission lines in this country, namely, the flashing over of insulators due to fog, and the surges set up by lightning. We doubt, however, if those behind the grid appreciated those difficulties to the full at the outset. Lightning troubles in this country were apparently expected to be less severe than they have proved. The grant of £21,000 which the Board has made to the E.R.A. for researches on surge phenomena would probably have been made earlier if it had been realised at the beginning that even in this country adequate protection against lightning is necessary. That troubles arising from deposits on insulators were also somewhat under-estimated seems evident from the fact that in the summer the insulation of sections of the grid liable to fog or to industrial atmospheric pollution was reinforced by the substitution of special insulators of the anti-fog type, developed as the result of the Board's researches. During the fogs of the succeeding winter no flash-overs occurred on any of the reinforced sections; but how often the insulators have to be cleaned the Report does not state.

At the end of the year there were 129 existing selected stations. Following a re-investigation of the position in South-West England and in South Wales, which revealed that in the area the incidence of load had shifted and that the disposition of the original selected stations in relation to the load centres, was no longer satisfactory, seven additional stations in the South-West England and South Wales area were selected. Schemes adopted by the Board provide for the construction of thirteen additional stations as and when required. Progress made in the construction of the Fulham and Tir John North Station, Swansea, the Battersea extension, and the hydro-electric stations of the Galloway Water Power Company, is considered, but it is scarcely necessary, in view of recent articles, to say more than that in all these cases progress was satisfactory.

Directions were issued by the Board during the year for the extension of twenty-two selected stations by the installation of fourteen additional turbo-alternators with a total capacity of 535,000 kilowatts, and additional boilers with a total evaporative capacity of 8,275,000 lb. per hour.

Growth of the demand for electricity necessitated the provision of new supply points on the grid system. Construction of the Colchester-Clacton-on-Sea-Frinton-Harwich-Colchester secondary ring was begun, and at the end of the year the 11¼-mile section from Colchester to Clacton was completed and put into service. Construction of the secondary line from Three Bridges to East Grinstead was also begun. The additional 132 kV transforming station at Beddington, Surrey, was put into service. The 132/11 kV transformer bank at Wooler, on the Dunston-Galashiels line, which incorporates the latest design of oil-blast fuses, was also completed, and is proving satisfactory. Additional facilities for the supply of current to the Southern Railway were provided at Northfleet and Tunbridge Wells, and at the end of the year the work involved in providing similar facilities at Eastbourne and Hastings was nearing completion.

Progress was made with the work involved in the standardisation of frequency in the North-East England, Central England, and South-West England, and South Wales areas. Control rooms were tested under working conditions with satisfactory results, the automatic indicating equipment having proved of great value in the way of furnishing the control engineers with prompt and reliable information regarding system conditions.

General interconnection of generating stations through the grid has made it possible to control frequency variations to within a mere fraction of the statutory limits. As the frequency is now controlled on a time basis over wide areas, many A.C. consumers are now able to make use of synchronous clocks.

The maximum amount the Board is empowered to borrow with the consent of the Electricity Commissioners remains unaltered at £60,000,000. During the year the Commissioners consented to the Board borrowing £1,549,500 for the purpose of frequency standardisation, and £3,810,500 for general purposes.

The Faraday Lecture.

"ELECTRICITY in the Life of To-day" was the subject chosen by Professor E. W. Marchent for the Faraday Lecture he delivered at the ordinary meeting of the Institution of Electrical Engineers on April 4th. The electric telegraph, he explained, was described by Sir David Brewster in 1887 as the most precious thing science had given to civilisation. Since then electricity had found increasing uses in every department of daily life. Over 450 million pounds were now invested in electricity supply undertakings, whilst the Post Office controlled electrical plant to the value of 130 million pounds. The electrical industry was the fifth largest in the country. Electricity was employed for diagnosing diseases of the heart; it was used by the surgeon in his operations and by the physician for the treatment of disease; experiments with radium, which emitted charged particles of electricity, had proved it to be one of the most effective means of treating cancer.

The telegraph could now send ten messages along a cable to any part of the world in the same time as it took to send one message when the first Atlantic cable was laid. Great improvements had recently been made in the light-producing efficiency of electric lamps. When Swan produced the first incandescent carbon lamp in 1879 he obtained an efficiency of about 3 lumens per watt, whereas the figure for new discharge lamps was over 25. Electricity was used in almost every factory for driving machinery and providing light. The standard of illumination in a factory might now be as high as 30 foot-candles, instead of 2 or 3 as in the past. Electric lighting had always been the most convenient method of illumination, and it was now also the cheapest method.

Electricity had done more than anything to reduce domestic drudgery. In the modern home it was used for cooking, ironing, cleaning, washing, and for many other purposes. For one of the least pleasant features of the average English city to-day—namely, the pall of smoke that covered it—the domestic fire was largely responsible.

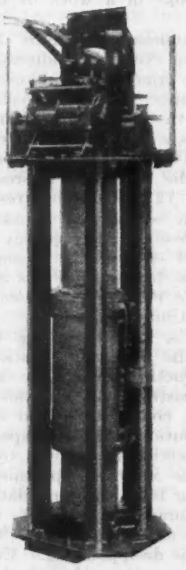
During the last ten years the average efficiency of electric power stations had improved by over 50 per cent. Whereas in 1923 the average number of units of electrical energy generated per ton of coal in British power stations was 800, in 1933 it was 1350—a figure larger than the best recorded in 1923. For that result the grid was largely responsible, for it had enabled the most efficient stations to supply the bulk of all electricity produced. In the best electricity stations, over 2000 units were now produced from every ton of coal. The thermal efficiency of those stations was approximately 30 per cent. Electricity offered the great advantage that it could produce heat wherever it was needed, and an electric heating installation was therefore both economical and efficient.

It was time that the burning of raw coal in our cities was forbidden, as it has been in New York for many years. The use of electricity for domestic heating would do more to free our cities of smoke than anything else, and it would help, as statistics had shown, to remove the causes of many chest diseases. Gas fires might eliminate smoke, but they did not get rid of sulphurous fumes. An inquiry conducted in Chicago before the railways were electrified revealed the fact that the worst offender from the point of view of smoke production was the steam railway locomotive. Electrification would add to the comfort of travel, provide work for many unemployed men, and it would pay. Electricity was being used increasingly on farms for improving winter egg production, driving agricultural machinery, drying hay, and for many other purposes. In gardens it was being employed for soil heating and the raising of early crops.

Many large generating stations were now time controlled and in consequence an electric clock connected to the mains kept as good time as the best chronometer. Electric traffic signals controlled a large percentage of the traffic in large towns, and were timed by the discharge of an electric condenser. Electricity made it possible to speak by telephone to 90 per cent. of all the world's telephone subscribers. But perhaps the greatest service electricity was now giving was broadcasting, which on the last three Christmas Days had enabled the King to address listeners in all the countries forming the British Empire.

Tests on Voltage Regulators.

ONE of the difficulties met with in the use of certain kinds of automatic voltage regulators on distribution circuits has been their inability to withstand the mechanical forces set up under severe fault and short-circuit conditions. According to an article by an engineer associated with the American General Electric Company, the feeder voltage regulator, presumably of the ordinary induction type, is more liable to injury, both mechanically and electrically, and is more liable to cause damage in a station than any other apparatus. The Ferranti moving coil regulator (described in THE ENGINEER of February 19th, 1932, and December 8th, 1933), in which voltage regulation is obtained by means of an isolated and short-circuited coil moving up and down an iron core over fixed coils, is claimed to overcome the difficulty because the mechanical forces on the fixed and moving coils are practically neutralised. Noise and vibration are also incidentally eliminated. All these regulators, with the exception of the largest manufactured, can be operated with a disc motor of the gramophone type. To prove that these regulators are capable of withstanding the severest short-circuit conditions, tests have recently been made. The regulator shown removed from its tank was selected at random from a number supplied to a large electricity undertaking in the South of England. It is designed to give a variable boost up to 11½ per cent. on a 50-kVA 240 single-phase circuit, and in all the tests the moving coil was set in the position giving the greatest mechanical forces, i.e., that corresponding approximately to a 10 per cent. boost. The regulator



MOVING COIL REGULATOR

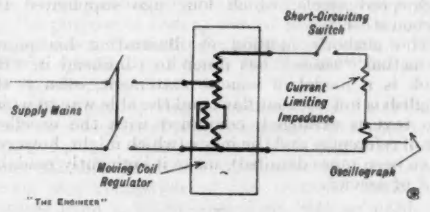
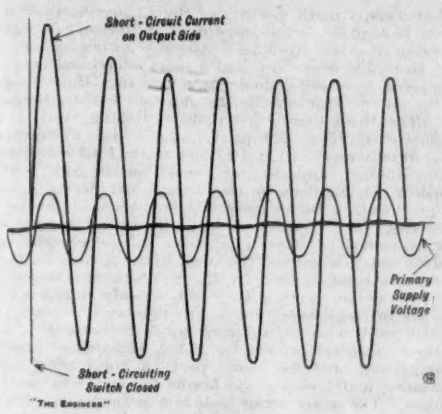


DIAGRAM OF CONNECTIONS TO REGULATOR

was connected to the supply mains and suddenly short-circuited on the output side, as indicated in the diagram of connections. Since in a normal distribution circuit the impedance of the system is sufficient to limit a short circuit current to about twenty-five times normal, several tests were carried out under these conditions and the oscillograms showed values varying from 27-30 times full load. After these tests the regulator was lifted from its tank and on careful examination no signs of damage could be discovered.

Subsequent tests were made at a voltage 10 per cent. above normal and without the limiting impedance in the secondary circuit. The short circuit currents were 55–57 times the normal full load value. At the instant of

switching in it was in some cases as much as 77 times the full load value owing to asymmetry or the "doubling" effect. A typical oscillogram obtained during the tests is reproduced. After the tests examination failed to reveal any damage done to the regulator, which operated both mechanically and electrically in the usual way, and it was dispatched to the customer without alteration or adjustment. The makers explain that under actual operating



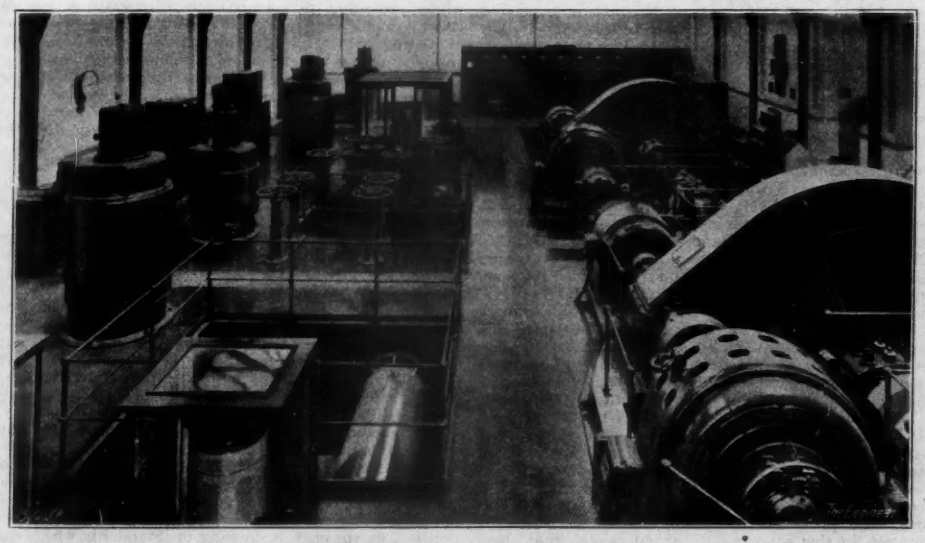
OSCILLOGRAM OF SHORT CIRCUIT TEST

conditions short circuit currents such as those obtained during the tests could not possibly occur, and the results, therefore, show conclusively the ability of the regulator to withstand the severest fault conditions without the need for current limiting reactors and notwithstanding the low impedance of the regulator itself.

Electrical Equipment at the New Barking Pumping Station.

THE new pumping station of the Ilford and Barking Joint Sewage Board has a dual electricity supply. One is obtained from the Barking generating station and the other from a private plant, consisting of Paxman-Crompton oil engine sets. The former E.H.T. supply is transformed down to 400 volts and fed into an eight-unit Crompton "Klad" switchboard. From the alternator bus-bars the 400-volt, three-phase supply is conveyed to the end of the L.T. board. Isolating change-over units housed in an integral chamber immediately above the "Klad" circuit board, enable a change-over to be made from one supply to the other in a few minutes. From the eight-unit board P.I.L.C. cables feed starter switch-contactor equipment.

The aggregate output of the motors for pumping and auxiliary purposes is 1990 h.p., and they are all 400-volt, three-phase, 50-cycle machines. Two dual motor units drive Tangye reciprocating pumping sets. Each unit consists of a 305 h.p. and a 69 h.p. Crompton auto-synchronous motor driving a common double helical gear, which drives a three-throw double-acting vertical reciprocating pump crank shaft. For heavy duty pumping the large motor is employed and the smaller motor for light duty. At each end of the fast-motion shaft of the double helical gear there is a Tangye patented adjustable mechanically operated pin type flexible coupling, which enables either motor to be disconnected at will. The motors and gear are erected on a combination cast iron bed plate



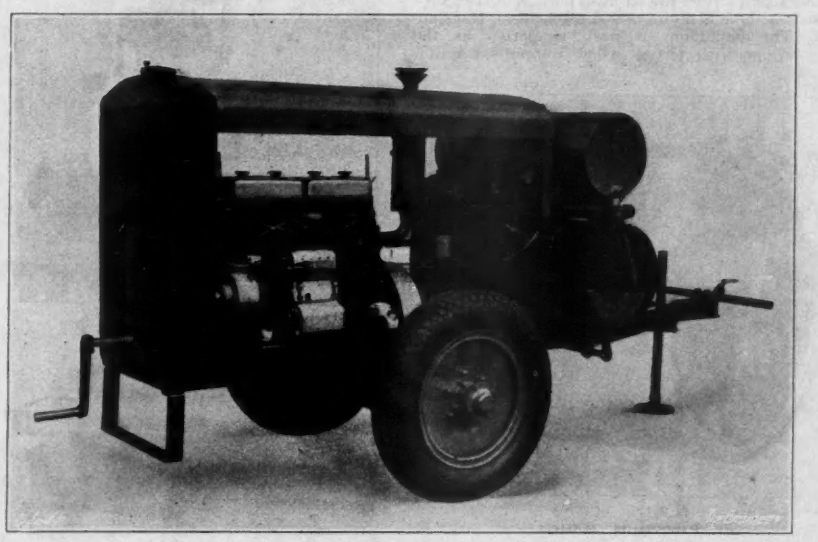
NEW BARKING PUMPING STATION

erected on the sill plate of the reciprocating pump frame, the pump barrels being about 20ft. below the pump-house level. Liquid hand-operated motor starters are employed and the exciter control pillars are mounted at the side of the main control gear.

All the other pumps in the station—shown in the accompanying illustration—are driven by Crompton-Parkinson vertical-spindle, auto-synchronous motors, with Michell thrust bearings. There is a 175 b.h.p., 750 r.p.m. motor; two 300 b.h.p., 600 r.p.m. motors; and two 130 b.h.p., 428 r.p.m. motors. With the exception of the first-mentioned motor, which operates at 0·8 leading power factor, all the motors work at unity power factor. For controlling these motors automatic contactor panels are employed, and are controlled by float switches in a float switch room where they are operated by float movements in sump pits adjoining the intake pipes. For the cabling throughout the station, and the supply and erection of the motors and switchgear mentioned, the contracts department of Crompton-Parkinson, Ltd., was responsible.

A Portable Compressor.

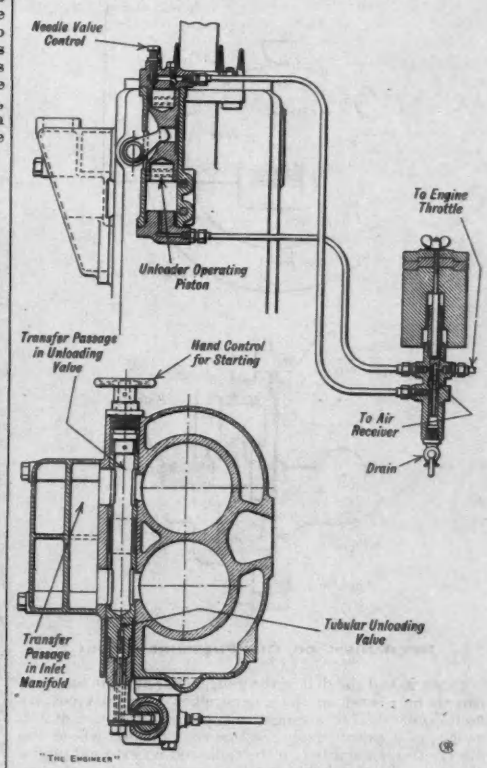
A RANGE of portable compressor units has recently been put upon the market by Sir W. G. Armstrong, Whitworth and Co., Ltd., of Newcastle-on-Tyne. They are designed to be operated by oil or petrol engines, running at 1100 to 1200 r.p.m., and the arrangement of the compressor is such that the volumetric efficiency is high at this speed, so that no intermediate gearing is necessary. The smallest



PORTABLE OIL ENGINE DRIVEN COMPRESSOR

unit of the range has a displacement of 130 cubic feet per minute. A unit driven by a four-cylinder oil engine is illustrated by the accompanying engraving, from which the neat arrangement will be observed. The point of greatest interest is, of course, the design of the compressor to run at a comparatively high speed. In earlier types of compressor, the suction and delivery valves were usually both placed in the cylinder head, and consequently their diameters were small, and the port areas, with a moderate valve lift, also small. In order to increase the speed of running without adversely effecting the volumetric efficiency, it was necessary therefore to increase the lift of the valves. This action, however, was likely to lead to valve breakages, with all the consequences necessitating a "shut-down" and replacement of the affected part. In the present design the delivery valve, alone, is mounted in the cylinder head. Free air is drawn through a water-jacketed belt round the lower part of the cylinder, through passages leading from the waist of the piston to the head, and thence through the suction valve, which is mounted in the piston itself. The arrangement is such, it will be seen, that it is possible to use the entire available area of the cylinder bore for each valve, so that large port areas are obtainable with small lifts. The fact that valve pockets overlapping the cylinder diameter are absent constitutes a further advantage in that a clearance volume of less than 1 per cent. of the swept volume is obtained, with a consequent increase in the volumetric efficiency. The valves themselves are of the concentric ring type, spring loaded, the suction valve being inertia-operated and the delivery valve opened by compression.

The objections to throttling the suction inlet to a compressor when it is desired to "unload" are well known. To avoid these disadvantages, the designers of this compressor have so arranged the unloading gear that air trapped within the cylinders is pumped back and forth between them when the unloader has operated. The unloading device is illustrated in the drawing. Situated in a housing running alongside the upper ends of the two cylinders there is a Corliss valve, which carries slots communicating with the compression chambers. When the pressure in the receiver exceeds a predetermined figure a relay, to be described later, operates and rotates the Corliss valve through 90 deg. By this action, as will be seen from the drawing, the two cylinders are put into communication with one another. The Corliss valve is operated by a small double-ended piston moving in a vertical cylinder, the ends of which are connected by small-bore pipes to the unloader relay. The latter consists of a small loaded piston valve, upon the under side of which the pressure of the air in the receiver acts. When in its raised position it allows air from the receiver to flow to the engine throttle to slow down the engine to idling speed, and also admits air to the underside of the piston in the Corliss valve operating cylinder. At the same time the upper end of this cylinder is opened to atmosphere. When the receiver pressure falls, the piston valve falls to the lower position. The connection to the engine throttle is at once opened to atmosphere, so that the engine speeds up; the lower end of the operating cylinder is also opened to atmosphere; and air from the receiver travels towards the upper end of the same cylinder. Direct access to the cylinder is, however, barred by a ball valve and the air has to find its way therein through a small adjustable needle valve, by the use of which the rate at which the compressor takes up the load again may be altered to suit the characteristics of the engine. It is worthy of note that all the unloader parts are accessible without opening up the cylinders, and that no springs are used in the unloading mechanism.

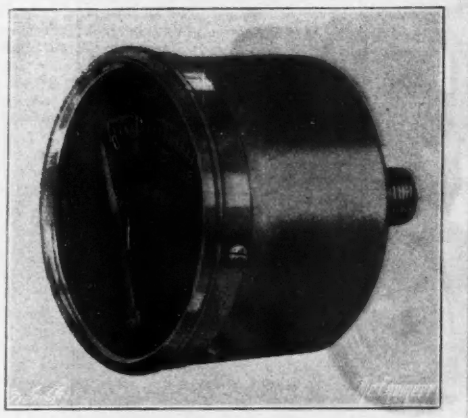


THE UNLOADING DEVICE

We need not refer to details of the arrangement of the various parts on the frame, since the general scheme can be observed in the tone engraving. Mention should be made, however, of the fact that the radiator is built up of renewable sections, and that its headers are divided into two parts. Four sections take the engine cooling water and two sections the compressor cooling water. Each circulation is maintained by a separate water pump. In order to facilitate starting when an oil engine drive is adopted, connection between engine and compressor is made through a centrifugal clutch.

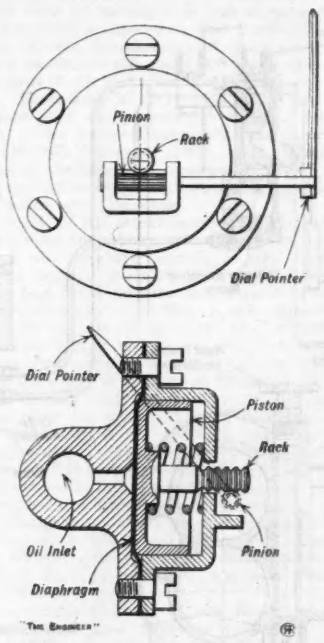
An Improved Oil-Pressure Gauge.

We have recently inspected a useful pressure gauge manufactured by J. Richards and Sons, Ltd., of Croydon, under licence from Mr. A. A. Sidney. As shown in the photograph and drawings we reproduce, the instrument is strongly built to stand up to arduous working conditions. Oil is led from the engine up a small passage to impinge on a diaphragm, which is bolted into the joint in the body of the mechanism. Here the oil-filled portion of the gauge ceases, and as there is no immersed mechanism, leaks are unlikely. The diaphragm is itself supported at the rear by the operating piston, which compresses a calibrated spring and operates a rack and pinion rotating the gauge pointer. As the passage through which the oil impinges on the diaphragm is small relatively to the piston area, the pointer movement is efficiently damped, and no sudden pressure is likely to shake the pointer excessively. Overloading the gauge is also harmless, as the piston in the extreme position butts firmly up against the casing, while supporting the entire diaphragm on its crown, making a solid wall against a further increase of pressure.



OIL-PRESSURE GAUGE

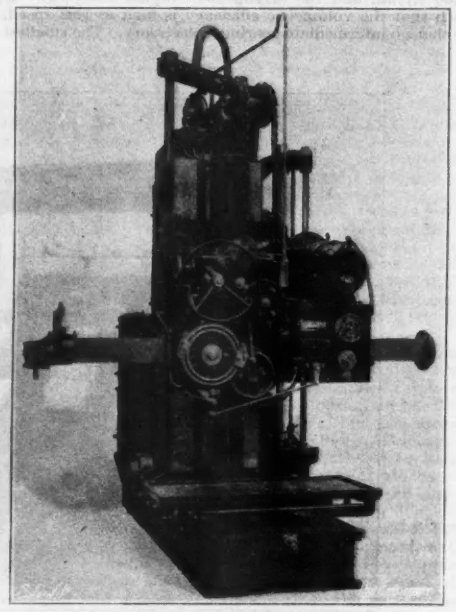
As the pointer-operating mechanism is independent of the oil, no difficulty arises in providing a flexible drive between it and the dial of the gauge, enabling the mechanism to be placed on the engine when long oil pipes are undesirable. This arrangement permits the use of the gauge as a petrol gauge on motor vehicles, where the mechanism is mounted on the tank and no external piping is used. It also lends itself to marine and stationary work, where duplicate dials are provided. We understand that the makers are also manufacturing a combined pressure and vacuum gauge on the same principle.



MECHANISM OF OIL-PRESSURE GAUGE

A Portable Draw-Cut Shaper.

The machine illustrated by the accompanying engraving is a 48in. stroke portable draw-cut shaper, made by the Butler Machine Tool Company, Ltd., of Halifax. This type of machine will take a heavy cut with either a push or a draw motion and can also be arranged for boring and milling. The traverse of the saddle is not restricted either vertically or horizontally, and a full range of milling and boring feeds can be provided in addition to power traverse to the ram in any direction. At the back the whole equipment for the forced field reversing motor drive is mounted on the machine. The 15 h.p. motor transmits power to either of two vertical shafts, one for shaping and one for milling. The ram, which is made of forged steel and has driving teeth machine cut from the solid, has a large range of automatic vertical and horizontal feeds. The pendant control stops, starts and inches the ram, the stroke of which is controlled from the dial to be seen in the engraving. Cutting speeds from 15ft. to 60ft. per minute and return speeds of 35ft. to 70ft. per minute are available. On the saddle there is the panel containing the main speed regulators; those for the auxiliary motor operating the power traverse; and the main reversing switch operated from the dial. As the boring bar is permanently located inside the ram, the machine can be quickly changed over from shaping for milling and boring. The spindle is driven by the 15 h.p. reversing motor through a gear-box at the end of the ram, and its speeds are variable between 2½ and 140 r.p.m. Feeds are obtained from the auxiliary variable speed motor and range from ¼in. to 30in. per minute. By the operation of a switch the ram is quickly withdrawn after being on milling. The machine is mechanically and electrically interlocked throughout.



48-INCH PORTABLE DRAW-CUT SHAPER

SIXTY YEARS AGO.

The Frenchman Gramme will probably for all time continue to receive a large measure of credit as one of the pioneers in the invention of the direct current magneto-electric machine or dynamo. There can however be little doubt that he was a plagiarist, conscious or unconscious, and that the idea of the ring type of armature associated with his name was anticipated by some ten years by Dr. Antonio Pacinotti of the University of Pisa the centenary of whose birth was recently celebrated by the Italians. Gramme may have made his invention independently of Pacinotti but there is unassailable evidence that the fact that he had been anticipated must have become known to him almost as soon as he published particulars of his machine. Gramme's communication entitled "Sur une Machine Magneto-Electrique Produisant des Courants Continus" was published in *Comptes Rendus* Vol. 73 in the year 1871. A month later Pacinotti sent a note to the French Academy of Sciences with the result that on a later page in the same volume of the Academy's "Proceedings" there is to be found a note entitled: "Une Machine Electro-Magnetique Construite en 1860 d'après le Même Principe que la Machine de M. Gramme." Gramme took out a patent for his machine in this country in 1870. In our issue of April 2nd 1875 we printed a letter from H. Wilde—himself a pioneer in the development of the dynamo—in which the validity of Gramme's patent was challenged. Wilde stated that the machine constructed by Pacinotti in 1860 was made for the Cabinet of Technological Physics of the University of Pisa and that it had an armature consisting of a closed ring, wrapped round with a series of small coils of insulated wire in the same manner precisely as in Gramme's machine. It employed either permanent or electro-magnets. Our correspondent also directed attention to the efforts made during the previous two years to exploit Gramme's invention in this country. It would appear that those responsible for its exploitation had tacked on to the original invention the principle of "electro-dynamic accumulation"—that is to say Siemens' and Wheatstone's discovery that the residual magnetism of an electro-magnet could be used to build up the magnetising current. With this addition the speculative promoters established "The Electric Power Company Ltd.," with a nominal capital of £100,000. Permission was obtained to exhibit an electric light on the clock tower of the Houses of Parliament but in spite of this and other publicity, the public refused to respond in adequate measure to the company's prospectus. A new company "Gramme's Magneto-Electric Company Ltd." was subsequently formed with a nominal capital of £250,000 of which the vendors of the Gramme invention were to receive £145,000. Wilde felt that it was his duty to publish these facts and that a knowledge of them would doubtlessly prove of public advantage.

THE ENGINEERS' GERMAN CIRCLE.

The twenty-ninth meeting of the Engineers' German Circle took place at the Institution of Mechanical Engineers on Monday, April 1st. About sixty-five members and visitors were present, and a most interesting lecture was given by Reichsbahndirektor Dr. Ing. Hans Culemeyer, of the Deutsche Reichsbahn Gesellschaft, Berlin, on "The Road Carrier for Railway Rolling Stock: A Transport Problem and its Solution." Dr. Culemeyer was officially welcomed by Dr. Bielfeld, the First Secretary of the German Embassy, who spoke on the good work which was being done by the London and Berlin circles in promoting a better understanding between the two countries. Dr. Culemeyer, with the aid of numerous lantern slides and three films, described the problem he had set out to solve and the latest forms of road carriers which are being utilised by the Reichsbahn authorities in five German cities. There are already fifteen road carriers in commission, and a like number is shortly to be delivered, while thirty more are to be ordered. The lecturer described carriers for 20-ton wagons and heavy rolling stock, and the means provided for loading and unloading and lowering the height for travelling under bridges. The newer forms include a self-propelling road carrier which has a 65 b.h.p. horizontal opposed-piston engine, while self-tipping carriers are also nearing completion. The use of these interesting vehicles was admirably illustrated, and a good discussion followed, which was succeeded by an informal dinner at the d'Abernon Club, 6, Carlton House-terrace.

BRITISH STANDARDS INSTITUTION.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

ENGINE-TESTING EQUIPMENT.

No. 412—1935. The British Standards Institution has recently issued a revised and amplified edition of British Standard Specification No. 412. In the revised specification no modifications have been made to the existing requirements, but two new sections have been added. The first of these deals with the size and form of thread to be used for the connections to all engine-testing fittings, such as pipe bosses, thermo-couples, &c., with the object of securing interchangeability of testing equipment. The other relates to indicator gear which is broadly grouped into two classes according to the method of operation. Recommended proportions for the levers when lever operated, are given, together with limits of accuracy of the gear.

STEEL CASTINGS FOR GENERAL ENGINEERING PURPOSES.

No. 592—1935. The British Standards Institution has just issued a Specification for Steel Castings for General Engineering Purposes (B.S.S. No. 592—1935). Although there have been in existence for a number of years British Standard Specifications for steel castings, these have, up to the present, always been confined to steel castings for particular requirements, such as for railway, automobile, and marine work. In the preparation of the new specification every endeavour has been made to co-ordinate the requirements of the three existing specifications, so that, whilst providing an adequate range of castings for the general engineering user, it does not multiply the grades of castings which manufacturers have to produce. The specification has been modelled to a considerable extent on B.S.S. No. 30, Castings for Marine Purposes, but as that specification was prepared over twenty-five years ago, a number of modifications have been necessary in order to provide an up-to-date specification with an adequate range of castings.

GENERAL PURPOSE LABORATORY THERMOMETERS.

No. 593—1935. The British Standards Institution has recently issued a Specification for laboratory thermometers for general purposes. The British Standard series, which has been drafted as far as possible to fall into line with existing standards, may be divided into four classes as follows:—Series A, accurate thermometers with zeros, covering ranges of about 30 deg. Cent., and divided to 0·1 deg. Cent.; Series B, similar to Series A, but with ranges of about 60 deg. Cent., and divided to 0·2 deg. Cent.; Series C, thermometers for less accurate work, without zeros, covering ranges of 100 deg. Cent., and divided to 1 deg. Cent. (the thermometers in this series are intended for use when compactness is essential); Series D, thermometers covering the complete scale from 0 deg. Cent. up to their respective maximum temperatures, and divided in a manner suited to each range. The Committee responsible for the preparation of this Specification is now engaged in drawing up Standards which will include thermometers for meteorological, bacteriological, and clinical purposes, &c.

STEEL SHEETS FOR TRANSFORMERS FOR POWER AND LIGHTING.

No. 601—1935. A British Standard Specification has been issued covering steel sheets to be used in the cores of transformers for power and lighting. The specification provides for two standard sizes of sheets of one standard thickness with the appropriate tolerances. In addition to the clause governing the general quality of the steels, clauses and appropriate methods of test are included for brittleness, ageing, losses, and permeability.

High-Pressure Marine Boilers.*

(Continued from page 313.)

THE LA MONT BOILER.

By D. W. RUDORFF, Dipl. Ing.

THE outstanding characteristic of the La Mont boiler is the use of forced water circulation through the boiler tubing. Fig. 6 shows diagrammatically how this is accomplished. The boiler water passes from the boiler drum into the suction side of the circulating pump supplying the differential pressure required to overcome the friction loss in the boiler circuit. This friction loss includes

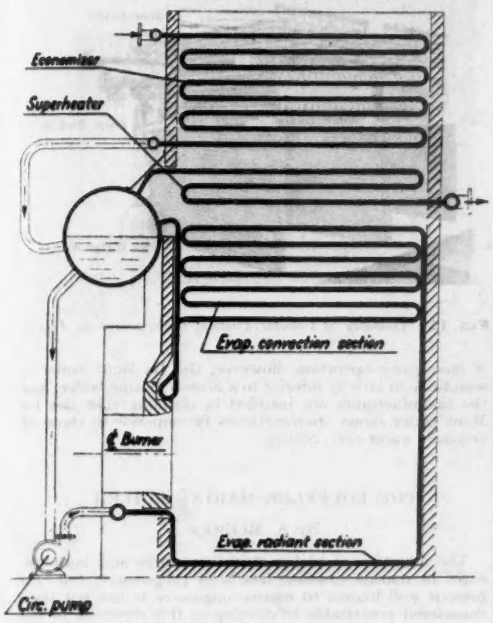


FIG. 6—*Typical Boiler Circuit.*

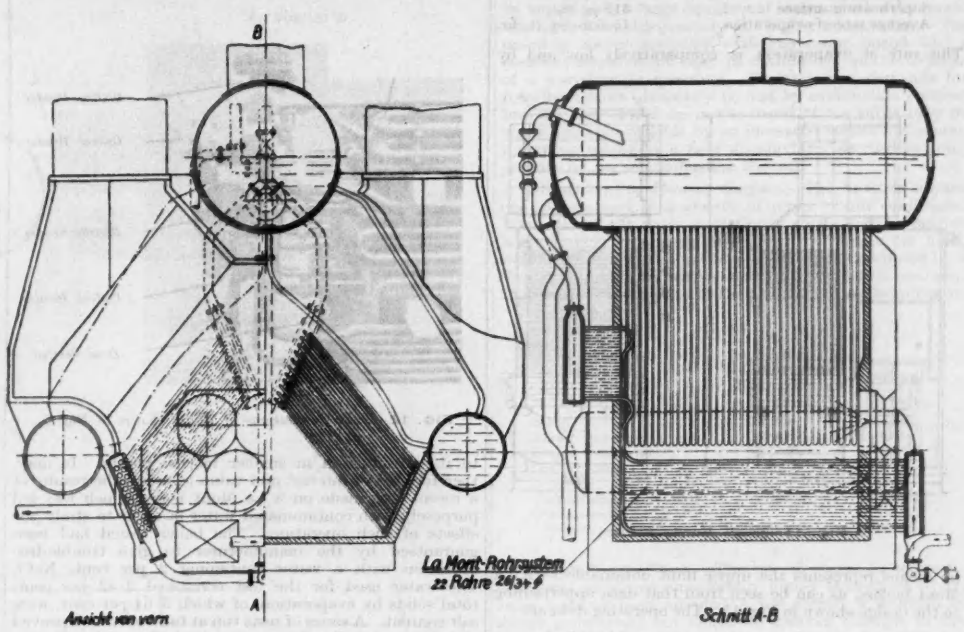


FIG. 9—*La Mont Water Walls Installed in a Water-Tube Marine Boiler.*

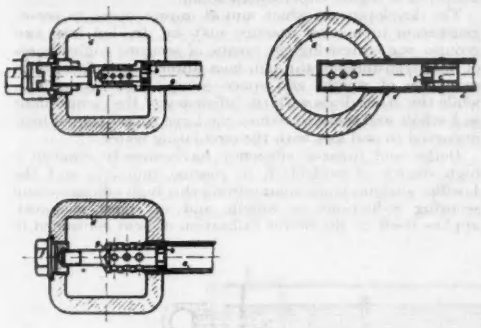


FIG. 7—*La Mont Nozzles.*

that caused by the orifices situated in the tube inlets. These orifices (Fig. 7) with which each boiler tube is equipped, serve the purpose of apportioning the water supply to the tubes in accordance with the heat absorption of each tube.

As a rule, the water circulation through the individual boiler tube is so adjusted by proper dimensioning of the orifice that at normal boiler load each tube receives eight times as much water as steam generated in the tube. By this ratio, high velocities of the steam-water mixture in the boiler tubing are ensured at all loads so that overheating of the tubes is made impossible even under the most severe conditions.

Following the boiler circuit we see that the water-steam mixture issuing from the boiler tubing is discharged into the boiler drum, where water and steam are separated. While the steam is drawn off into the superheater, an equivalent quantity of feed water is supplied to the boiler circuit by the feed water pump. Control of the feed water supply is accomplished by any of the standard types of feed water regulators used to maintain a constant water level in the boiler drum. Therefore no special types of feed water regulators are required and the circulating pump remains the only feature which distinguishes the operation of a La Mont boiler from that of an ordinary boiler either of the Scotch marine or water-tube type.

Besides preventing overheating of the tubes, the high velocity of circulation also acts as an efficient agent against the accumulation of scale, a point which will be discussed later.

As to the pressure drop which must be overcome by the circulating pump, this does not exceed 35 lb. per square inch, so that in the average boiler the power consumption of the pump drive amounts only to about ½ per cent. of the energy output of the boiler.

Other advantages are also claimed for the La Mont system of forced circulation besides those just mentioned. With regard to the operating characteristics of the boiler it remains to be added that the starting time of such boilers from cold is extremely short, an advantage mainly due to the equalisation of metal temperatures throughout the boiler and the consequent suppression of expansion stresses; this results from the constant circulation of the boiler water, whereby a uniform warming up of boiler tubing, headers, pipe connections, &c., is achieved.

The principle of natural boiler circulation has hitherto imposed a number of important restrictions upon the designer. Those relating to boiler-tube diameter, tube inclination, and length are in the case of the La Mont boiler practically eliminated. Small tube diameters and great tube lengths as they are used in the design of the La Mont boiler are known to have highly beneficial effects upon heat transfer, cost of construction, and boiler weight; the latter feature is of special importance in the design of naval boilers. These two features, combined with the unimportance of the tube inclination, allow a wide latitude of design when it becomes necessary to adapt the boiler lay-out to specified conditions and restrictions of space, such as often occur in the conversion of ship propulsion from Diesel to steam, and the replacements of old boilers by others of higher output and pressure, &c.

As to the low boiler unit weights obtainable with the La Mont system, the claim of the manufacturers that they obtain these low weights without any sacrifice of either boiler efficiency or service dependability, or by resort to radical departures from standard boiler practice, has to be admitted. It is particularly fortunate that forced circulation of the boiler water is not confined to any particular boiler pressure, so that it is applicable over the whole range of pressures from the most conservative in marine plants of yesterday and to-day to the most extreme pressures for which the plant of the future may be built.

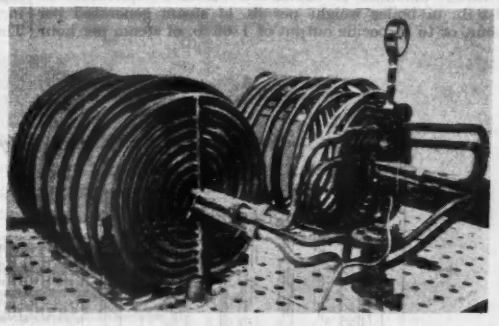


FIG. 10—*Furnace Coils.*

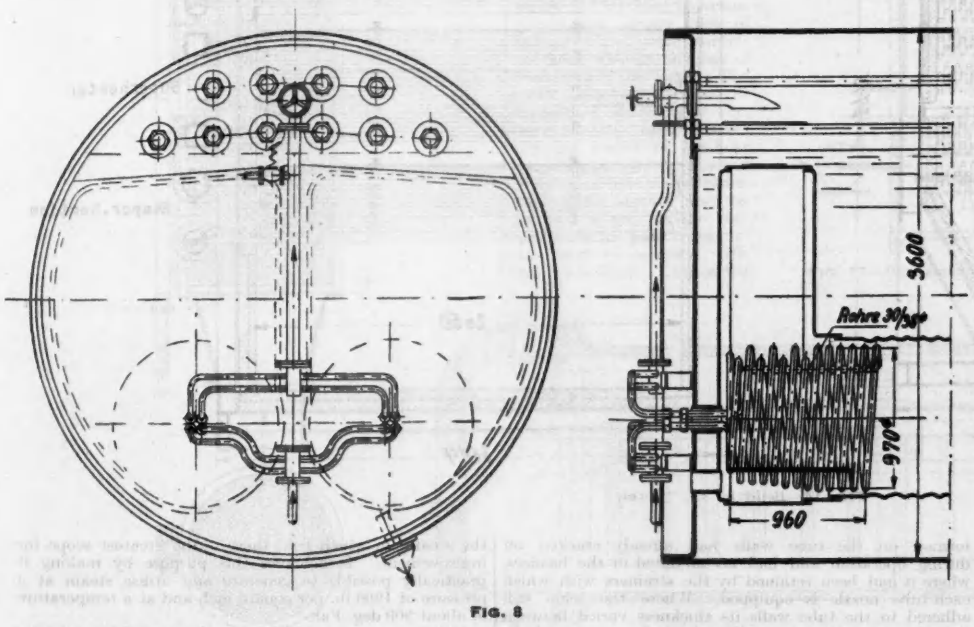


FIG. 8

A few examples may serve to show the various kinds of marine installations in which La Mont boilers are in use. Figs. 8 and 10 show how the La Mont system can be employed to facilitate the conversion of cylindrical boilers to firing with pulverised coal. In this case the La Mont cooling coils serve to reduce the furnace temperature. The surprising feature of this arrangement is that, as continuous operation for a period of more than a year has shown, no scale formation takes place in the cooling coils, although untreated river water is used as feed. The water used for the boiler in this and in another boat of the same type is taken from the river Rhine. Average analyses show the water to be of approximately 10·6 English degrees of permanent hardness and 50 deg. of total hardness. Fig. 9 shows how La Mont water walls can be used to increase the capacity of existing marine boilers. The installation shown is identical with those placed in the auxiliary boilers of the Hamburg-American liners "Albert Ballin" and "Deutschland," which had been found to be of insufficient capacity for the supply of steam to the auxiliary equipment, such as turbo-generators, winches, refrigeration equipment, &c., while the steamer was in port. Due to overloading of the boilers prior to installation of the water walls boiler uptake temperatures as high as 930 deg. Fah. had been observed, but the La Mont installation caused a drop to about 570 deg. Fah. These water walls have given satisfactory service since the date of their installation in 1931.

As to complete La Mont boiler installations, Fig. 11 shows a small plant installed in the steamer "Juno." Operating pressure is 180 lb. per square inch, the steam output is 5500 lb. per hour, the heating surface of the boiler 540 square feet. Fig. 12 shows how the tube connections between tubes and headers are made and arranged, while Fig. 13 gives a picture of the assembly of the tubular part of the boiler.

* Symposium. Institute of Marine Engineers, March 12th, 1935.

A somewhat larger installation is that of two powdered-coal-fired boilers for the steamer "Nicea." Fig. 14 illustrates the design of these boilers, which are equipped with ample radiant evaporating surfaces followed by coil-shaped evaporating surfaces of the convection type. The firing arrangement is that of the inverted flame type which is similar to that frequently used in land plants. The most important data of these boilers are :—

Steam output of each boiler	11,000/hr.
Steam pressure	255 lb./sq. in.
Steam temperature	626 deg. Fah.
Evaporating surface	710 sq. ft.
Superheating surface	312 sq. ft.
Average rate of evaporation	15·5 lb./sq. ft./hr.

This rate of evaporation is comparatively low and by

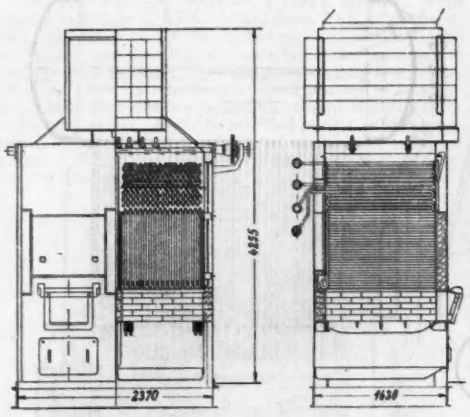


FIG. 11—*Small Marine Boiler.*

no means represents the upper limit obtainable with La Mont boilers, as can be seen from that data appertaining to the design shown in Fig. 15. The operating data are :

Steam output	88,000 lb./hr.
Steam pressure	750 lb./sq. in.
Steam temperature	806 deg. Fah.
Evaporating surface	2,320 sq. ft.
Superheater surface	1,830 sq. ft.
Economiser surface	2,580 sq. ft.

The total service weight of the boiler, including water content, amounts to 52,800 lb., which is equivalent to 0·6 lb. of boiler weight per lb. of steam generated per hour, or to a specific output of 1·66 lb. of steam per hour per lb. of boiler weight. It is remarkable that in spite of this low weight the boiler efficiency amounts to 86·2 per cent. at full load, although the average evaporation is no less than about 38 lb. of steam per hour per square foot of evaporating surface.

Another somewhat different application of the La Mont system is that relating to waste heat boilers in conjunction with marine Diesels. Fig. 16 shows the typical design of such an exhaust gas boiler. Exhaust boilers of this type are installed in several Diesel-propelled ships of which the M.S. "Toulouse," "Modjokerto," and the M.T. "Svithiod" may be mentioned. In this type the boiler surface is composed of a number of stacked-up, flat-coil spirals, each receiving an apportioned water supply from the distributing header.

Scaling, priming, and foaming of water-tube boilers used in ships have always presented a serious problem to the marine engineer, particularly as these phenomena can become rather serious whenever condenser leakage or other circumstances demand a boiler emergency operation with feed contaminated with salt water or even with pure salt water. As a matter of fact, the inferiority of the water-tube boiler in this respect to the cylindrical boiler has for a long time presented a serious obstacle

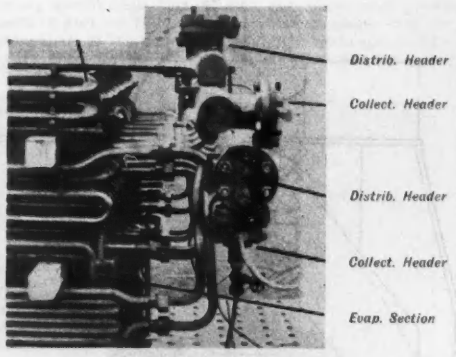


FIG. 12—*Tube Connections of Boiler shown in Fig. 6.*

to its introduction in smaller marine plants. It may, therefore, be of interest and value to relate the results of a recent test made on a La Mont boiler which was fed purposely with contaminated water in order to study the effects of such operation. The boiler tested had been guaranteed by the manufacturer to give trouble-free operation with a water containing 2 per cent. NaCl. The water used for the test contained 3·82 per cent. total solids by evaporation, of which 3·64 per cent. were salt content. A series of tests run at full boiler load proved that it was possible to operate the boiler with salt concentrations as high as 15 per cent., a result which was in excess of the most optimistic expectations. Samples of the saturated steam taken periodically during the tests contained salt concentrations of 2·8–29·0 parts per million and total solids of 16·8–48·4 parts per million, the variations being due to the gradual building up of a higher boiler water concentration, which was gradually increased from 3·6 per cent. to 15·0 per cent. salt content. These figures indicate that the moisture content of the steam delivered by the boiler remained very low even under the most severe conditions.

After the boiler had been in operation for twelve hours it was shut down and the inner surfaces of headers and tubing were examined. As was to be expected, some scale accumulation could be found in the boiler tubing. A portion of the scale formed on the tube walls had already cracked off during operation and had accumulated in the headers, where it had been retained by the strainers with which each tube nozzle is equipped. Where the scale still adhered to the tube walls its thickness varied between 0·1–0·2 mm. After inspection the boiler was put back into service again, the feed being changed to the fresh water supply available, which was treated with caustic soda and trinatrium-phosphate. Another inspection of the boiler tubing made after 100 hours' operation showed that the scale on the tube walls had now almost entirely disappeared, its place being taken by the exceedingly thin film typical of boilers fed with chemically treated water.

It need hardly be pointed out that the purpose of this test was merely to ascertain whether emergency operation of a La Mont marine boiler with salt water was feasible for a reasonable length of time. It must be admitted that the outcome of these tests was highly satisfactory. A permanent operation of this type of boiler or of any other type of water-tube boiler with salt water is, of course, out of the question and was not attempted. For such periods

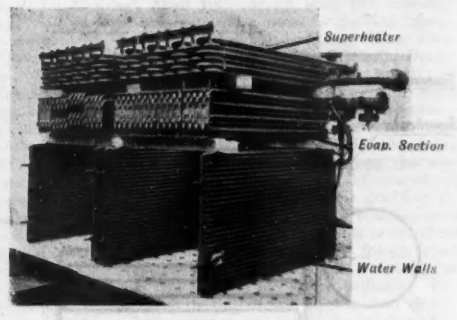
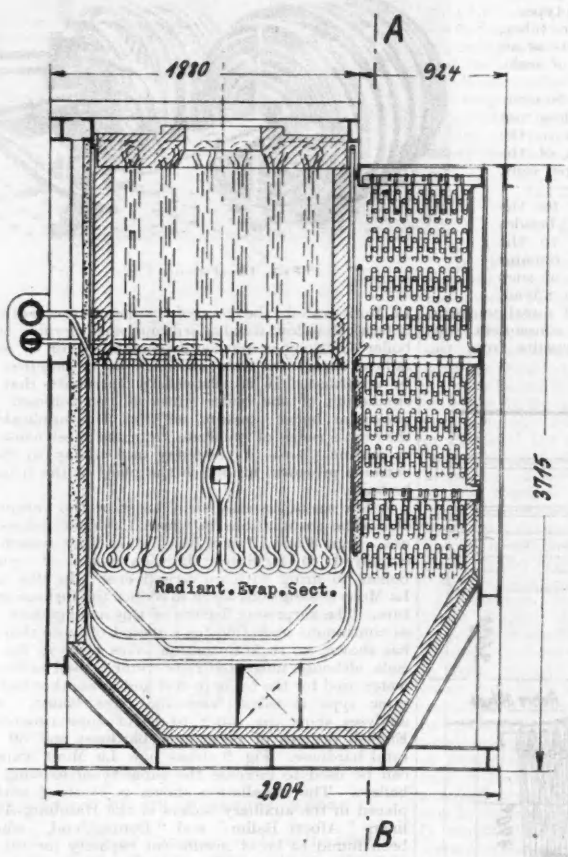


FIG. 13—*Assembly of Tubular Parts of Boiler shown in Fig. 6.*

of emergency operation, however, the La Mont boiler is seen to be in no way inferior to a Scotch marine boiler, and the manufacturers are justified in claiming that the La Mont boiler shows characteristics far superior to those of ordinary water-tube boilers.



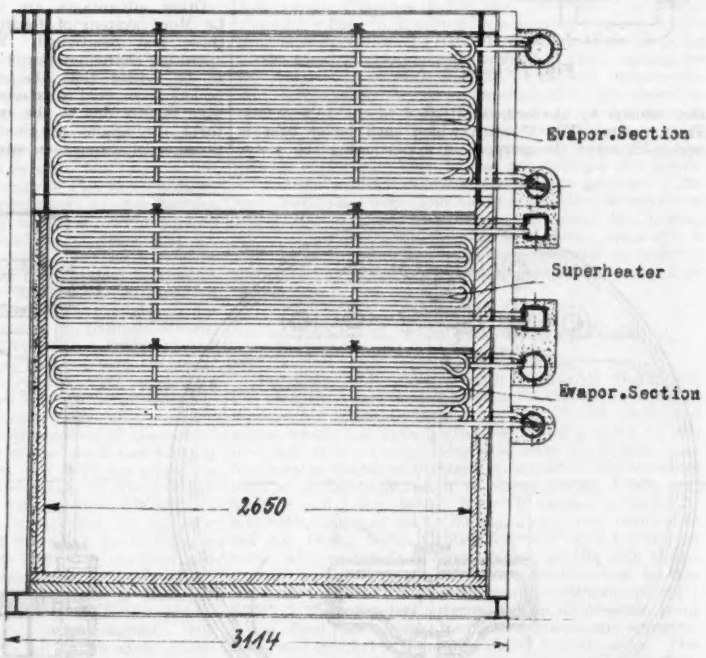


FIG. 14—*Boiler for s.s. "Nicea."*

THE LOEFFLER MARINE BOILER.

By S. McEwen.

The adoption of higher steam pressures and temperatures in marine practice has been progressive, but, for reasons well known to marine engineers, it has not been considered practicable to develop in this direction to the same extent as has been found to be both possible and advantageous in land practice.

Considerations of weight and space occupied by equipment impose their particular limitations in marine as compared with land practice, and, further, the nature of the demands made on a marine power plant for the purpose of reversing and manœuvring have tended to check the adoption of highly superheated steam.

The developments which aim at improvement in power generation in marine practice may be divided into two groups, one embracing the means of securing higher rates of heat transmission through heat absorbing surfaces with reduction of weight and space occupied by equipment, while the other deals with the efficiency of the power plant as a whole and seeks to reduce the large proportion of heat imparted to and lost with the circulating water.

Boiler and furnace efficiency have already reached a high degree of perfection in marine practice, and the Loeffler system, while maintaining this high efficiency and securing reductions in weight and in space occupied, applies itself to the better utilisation of heat contained in the steam, in which field there is the greatest scope for improvement. It achieves this purpose by making it practically possible to generate and utilise steam at a pressure of 1900 lb. per square inch and at a temperature of about 900 deg. Fah.

It is necessary to realise that the conditions requisite for high rates of heat transmission are opposed to the objective of the generation of steam at high pressure and temperature. In each case the limiting factor is the stress, due to pressure and to the temperature gradient, which the metal of the tubes can withstand. It is obviously impossible to adopt both high external and internal temperatures

with relation to the wall of a tube, and, at the same time, secure a high rate of heat transmission. Since the greatest scope for ultimate economy lies in the direction of high steam pressures and temperatures, the Loeffler system adopts a medium rate of heat transmission and the highest practicable internal temperatures.

The essential principles of the Loeffler system may be readily understood by reference to Fig. 17, which represents the system diagrammatically: S is a radial superheater enclosing a combustion chamber, N is a convection superheater, B is a boiler drum placed in any convenient position outside the boiler setting; the feed pump is represented by P, the economiser by V, and the air heater by L. A steam circulating pump U extracts steam from the evaporator drum B, forces it through the radiant and convection superheaters up to the points J and K, beyond which a part of the steam passes to the steam main while the remainder is returned to the evaporator drum B.

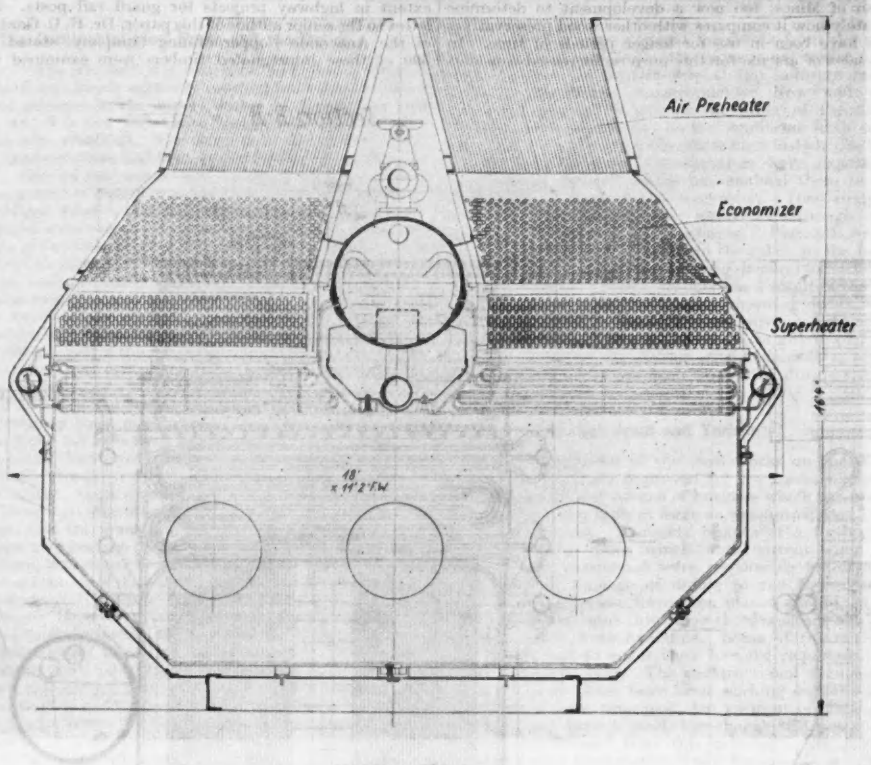


FIG. 15—*Marine Boiler.*

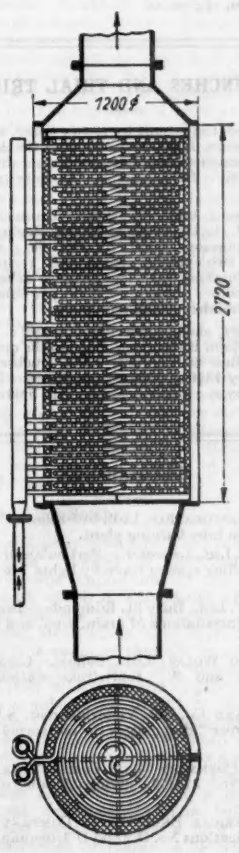


FIG. 16—*Diesel Exhaust Boiler.*

Superheated steam from the point J is forced to pass through the water in the drum B, giving up its superheat and producing an additional supply of saturated steam. Feed water from the economiser or, in the absence of an economiser, from the feed pump direct is forced into the steam line from K, wherein some evaporation takes place and a mixture of saturated steam and water enters the drum above the water level.

With the aid of this brief description the following features of the system may be appreciated. All the steam is generated in vessels not exposed to any external heat, while the tubes which are heated externally contain only clean, dry, and dense steam. Steam at a pressure of 1900 lb. per square inch has a specific volume of 0·21, and it is this low specific volume which makes it economically possible to circulate the steam by means of a pump. The velocity at which the dense steam is passed through the tubes is such as to ensure a small differential in temperature between that of the steam and the metal walls of the tubes. This velocity is of the order of 65ft. per second for maximum capacity and under these conditions 40,000 B.Th.U. can be transmitted per square foot of radiant superheater surface per hour without any risk of over-heating the metal. The entire absence of scale or deposit on the interior surfaces of the tubes ensures constant conditions for heat transference. In the absence of water circulation problems the heating surface may be disposed to provide the best conditions for heat transmission and to conform with any reasonable limitations imposed by nature of space available. For this system the purity of feed water assumes secondary importance, since all solid constituents are retained in the drum which is not subjected to external heat.

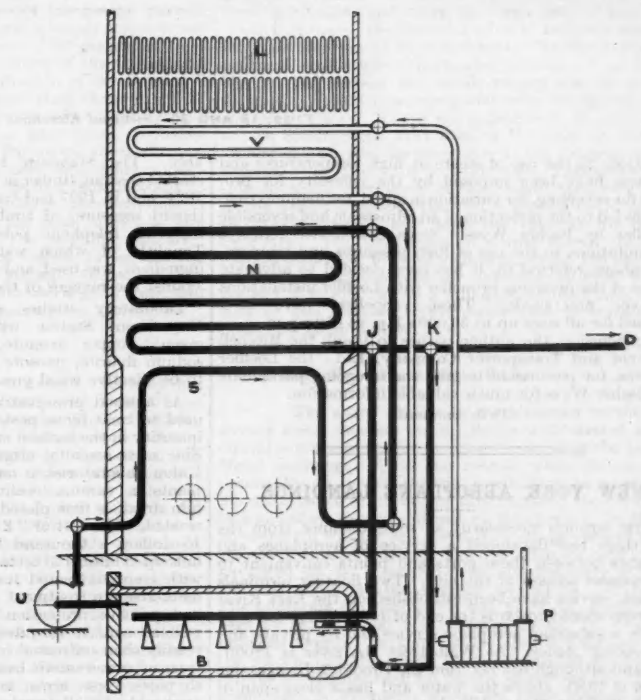


FIG. 17—*Diagrammatic Representation of Loeffler System Applied to Marine Boilers.*

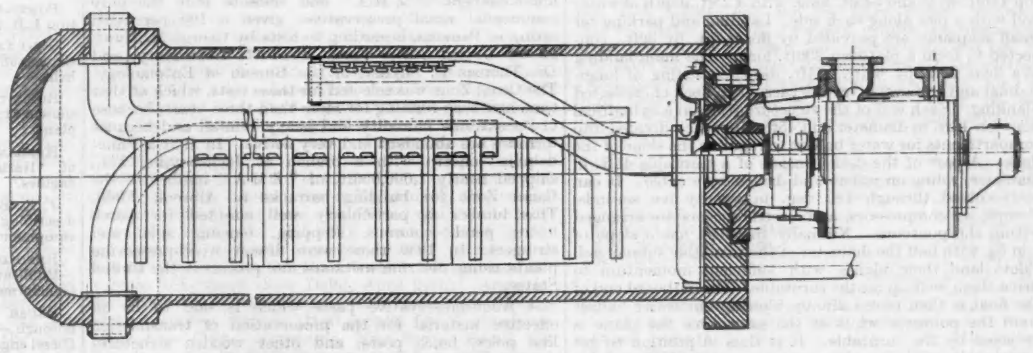


FIG. 18—*Evaporator Drum with Steam Circulating Pump for Marine Boilers.*

Steam Circulating Pump.—The steam pump is quite simple in construction and, for marine installations, is mounted on one end of the evaporator drum, as may be seen in Fig. 18. A single impeller rotates within a housing formed in part by the drum end. The main purpose of the pump is to circulate steam at the desired velocity through the system and, by variations in that velocity, to maintain a uniform final temperature of steam for delivery to the turbine at all loads. The control of temperature by pump speed is based on the principle that a given quantity of heat transmitted through a heat absorbing surface may be imparted to a large quantity of steam at a low temperature or to a smaller quantity at a higher temperature. The quantity varies instantly with the pump speed and a constant temperature may be maintained at the expense of a variation in quantity. Variations in demands for total heat must ultimately be met by combustion control, but the heat stored up in the metal of the tubes may be made quickly available by an increased velocity of steam, the tubes acting as a heat accumulator serving to compensate for lag in combustion control.

Arrangement of Heating Surface.—The heating surface can be arranged in a variety of ways to suit conditions. Figs. 19 and 20 show in section a small Loeffler marine boiler having a capacity of 40,000 lb. of steam per hour, which can be installed in the space normally occupied by a Scotch marine boiler with a capacity of 16,000 lb. per hour. The compact disposition of the heating surface is apparent.

TABLE I.

	Loeffler Boilers and Escher Wyss turbines.	H.M.S. "Acheron."
S.h.p.	34,000	34,000
Steam pressure	1,900 lb.	500 lb.
Steam temperature	897° F.	750° F.
Oil consumption at full power and including auxiliaries per s.h.p.	0·561 lb.	0·608 lb.
Oil consumption at cruising power per s.h.p.	0·627 lb.	0·92 lb.

Marine Power Plants.—The use of steam at temperatures and pressures considerably higher than those which have hitherto been adopted is not merely a problem of steam generation, but demands material changes in the design and arrangement of steam turbines. Provision for reversing and for variable speeds with new conditions of steam supply requires close co-operation with turbine manufacturers, and the development of the Loeffler system for marine practice has been favoured by such co-operation with Escher Wyss, of Zurich, who have been responsible for many developments of the greatest importance. Before dealing with their latest development it is interesting to compare the estimated performance of a Loeffler-Escher Wyss power installation, with cruising turbines and reversing stages in the main turbine, with the pub-

lished data relating to the power plant of a torpedo-boat destroyer.

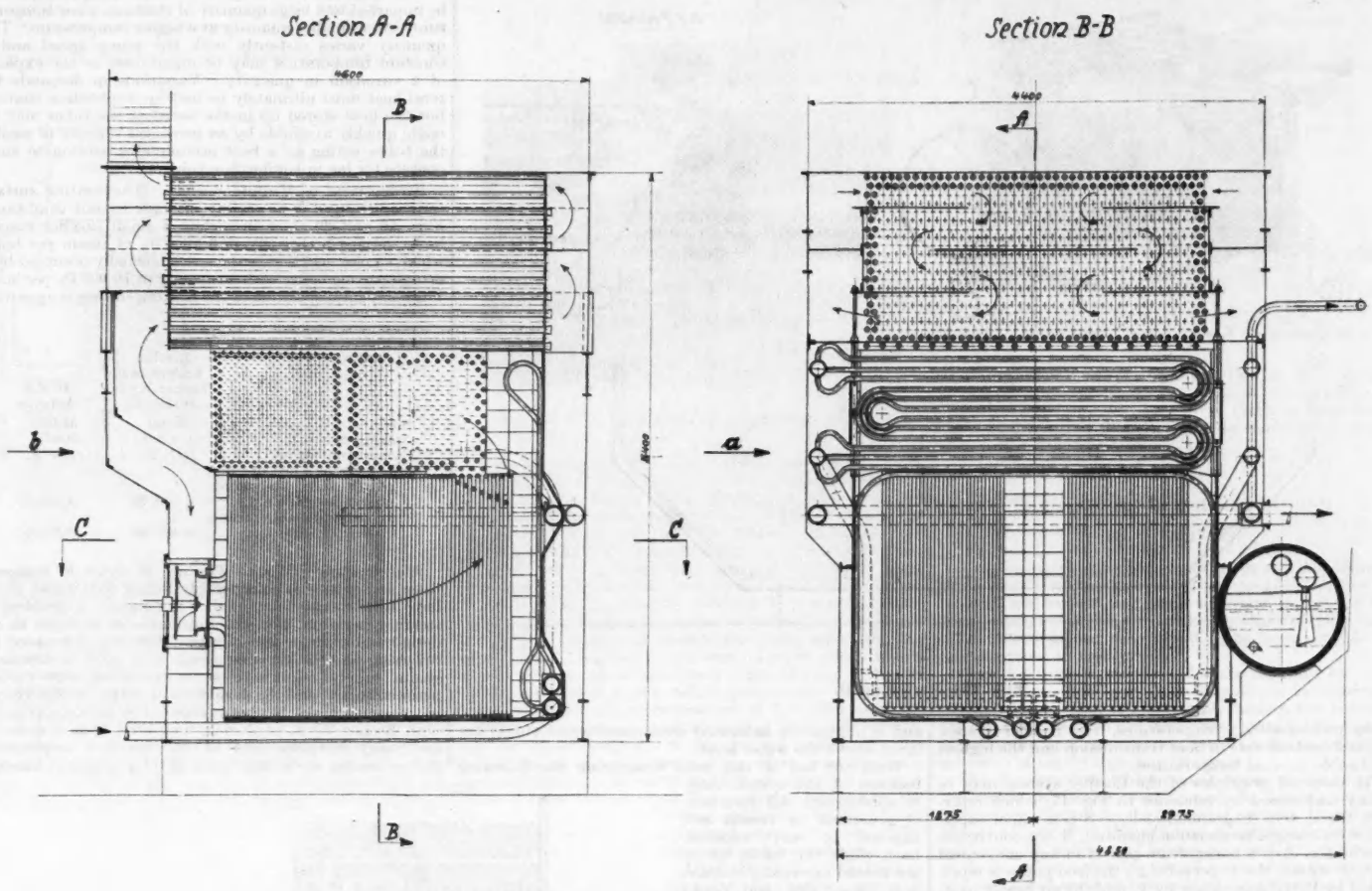
Full particulars of the trials of H.M. destroyer "Acheron" are given in THE ENGINEER of June 26th, 1931, and Table I gives some comparative figures.

It will be seen that at full power the fuel consumption of the "Acheron" is 8·3 per cent. higher than that of the Loeffler-Escher Wyss plant, while at cruising speed the fuel consumption of the "Acheron" is considerably higher.

Reversible Propeller.—The knowledge that many of the limitations to the use of steam at high temperatures and pressures have been imposed by the necessity for provision for reversing, for variation in speed, for manœuvring, &c., has led to the perfection of an adjustable and reversible propeller by Escher Wyss. Since this device removes the limitations to the use of high pressures and temperatures above referred to, it has been decided to advocate the use of the reversing propeller with Loeffler installations wherever practicable. These propellers have been designed for all sizes up to 50,000 s.h.p. at 450 r.p.m.

In conclusion, the author wishes to thank the Mitchell Conveyor and Transporter Company, Ltd., the Loeffler licensees, for permission to give the foregoing particulars and Escher Wyss for much valuable information.

(To be continued.)



FIGS. 19 AND 20—*Sectional Elevations of Loeffler Marine Boiler—40,000 lb. Evaporation.*

NEW YORK AEROPLANE LANDINGS.

WITH airports necessarily at some distance from the city, there has developed a service of aeroplanes and seaplanes between these ports and points convenient to the business section of the city. Two floating terminals for such service have been established on the East River and were opened towards the end of 1934. They are used also by a suburban aeroplane service and by private and sight-seeing planes. At Wall-street the river is 1800ft. wide and although not far from the Brooklyn Bridge, this bridge is 185ft. above the water and has a clear span of 1300ft., so that planes 15ft. high with a wing spread of 100ft. can pass under it with safety. The landing is in a slip 156ft. wide and 548ft. long, with a 25ft. depth of water and with a pier along each side. Landing and parking for small seaplanes are provided by floats 6ft. by 30ft., connected to form a platform 300ft. long. The main landing is a float 90ft. by 60ft., 15½ft. deep, consisting of longitudinal and transverse trusses carrying a deck of creosoted planking. Each end of the structure rests on a cylindrical pontoon 12ft. in diameter and 45ft. long, each divided into compartments for water ballast to regulate the slope of the deck. A part of the deck consists of a turntable 45ft. in diameter, riding on rollers and driven by a cable. It can be revolved through 180 deg. in twenty-five seconds. Pumps, air compressors, and electric motors are arranged within the pontoons. Normally the deck has a slope of 1 in 8½, with half the diameter of the turntable submerged. Pilots land their planes with sufficient momentum to drive them well up on the turntable. The outboard end of the float is then raised 2ft. by blowing out water ballast from the pontoon, while at the same time the plane is reversed by the turntable. It is thus in position to get away again, while its cabin entrance is at the high and dry end of the float, where a movable platform is adjusted for the passengers. At the land end of the slip is a building with waiting rooms, ticket offices, and other accommodations. A practically identical terminal is at the foot of 31st-street.

Arsenic as a Wood Preservative.

WITHIN recent years arsenic has been employed as a wood preservative with apparent success, although, generally speaking, it is, according to the United States Bureau of Mines, too new a development to determine accurately how it compares with other wood preservatives which have been in use for longer periods of time. In 1933, sales of arsenic for this purpose increased considerably. The Standard Fruit and Steamship Company started treating timber in its Honduras division in October, 1924, and in 1927 had treated approximately 7,000,000ft. (board measure) of timber, including cross ties, bridge material, telephone poles, and house-building lumber. Tanolith, of which sodium arsenite is an important ingredient, was used, and was said to give added protection against the ravages of the white ant.

Laboratory studies at the Arkansas Agricultural Experiment Station with copper acetoarsenite (paris green), copper arsenite, copper borate, zinc chloride, sodium fluorite, creosote, &c., showed the two arsenicals to be effective wood preservatives.

As a wood preservative, crude gray arsenic has been used to treat fence posts by farmers, who place a small quantity in the bottom of the hole before setting the post. Zinc meta-arsenite, originally developed in the Western Union Laboratories, is now employed in central treatment plants in various localities. The lumber, either air or kiln dried, is first placed in a vacuum and then pressure treated. The cost of "Z M A" treated lumber is perhaps 15 dollars a thousand board feet higher than that of untreated lumber in certain sections, comparing favourably with creosote-treated lumber in this respect. The zinc meta-arsenite treatment is claimed to provide permanent and positive protection against all forms of decay, as well as against termites or white ants. It burns less readily than untreated lumber and can be painted. This type of preservative has so far been applied principally to poles, cross arms, and mill timbers, but is equally applicable to all wooden building material and piles—except, perhaps, those employed in salt water—and to mine timbers. "Z M A" and creosote were the only commercial wood preservatives given a 100 per cent. rating in Panama, according to tests by George M. Hunt, of the United States Forest Products Laboratory, and Dr. Thomas E. Snyder, of the Bureau of Entomology. The Canal Zone was selected for these tests, which at that time had been running for more than three years, because of its extreme humidity and heavy rainfall and because termites are abundant and very active. In 1931 a Philadelphia concern with a branch at Jacksonville, Fla., shipped nearly 1,000,000ft. of "Z M A" lumber to the Canal Zone for building barracks at Albrook Field. This lumber is particularly well adapted for porch floors, porch columns, stepping, fencing, sills, and stringers. In 1930 there were fifteen wood-preserving plants using the zinc meta-arsenite process in the United States.

A wood-preservative paste which is said to be an effective material for the preservation of transmission line poles, fence posts, and other wooden structures coming in contact with the soil, is manufactured by the Anaconda Copper Mining Company from Cottrell-treater dust. The material is largely composed of arsenic, together with compounds of lead, copper, and zinc, and is sold as paste or in the form of dust, which can be converted to paste by the addition of 20 per cent. water by weight. The company recommends the dust for farm use and for all small jobs.

The Anaconda Copper Mining Company also operates a wood-impregnating plant at Rocker, Mont., for impregnating timber with a water solution of white arsenic. Timber so treated is used in the mines in Butte and for stubbing by the local power companies and to a limited extent in highway projects for guard rail posts. In a letter to the senior author of this paper, Dr. H. C. Gardiner, of the Anaconda Copper Mining Company, stated that 500 of these impregnated timbers were examined after being in service over five years without finding any indication of rot in any of them.

A new German wood preservative contains arsenic and chromium, chromates or chromic acid being added to fix the arsenic in the wood.

LAUNCHES AND TRIAL TRIPS.

CONCRETE, steel tug; built by Henry Scarr, Ltd. (controlled by Richard Dunston, Ltd.), to the order of the Associated Portland Cement Manufacturers, Ltd., London; dimensions, 75ft. by 19ft. by 9ft. 9in. Diesel engines, Newbury type; trial trip, recent.

PUCK, steamer; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Messrs. Zegluga Polska S.A., of Gdynia; dimensions, 243ft. by 36ft. 6in.; to carry cargo. Steam engine, two-cylinder compound reciprocating type, working in conjunction with low-pressure exhaust turbine on Bauer-Wach system; pressure, 210 lb. per square inch; constructed by the builders; trial trip, recent.

JEAN BRILLANT, single-screw motor vessel; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of La Cie de Transport du Bas St.-Laurent, Ltd., Quebec; dimensions, 163ft. by 29ft. by 18½ft.; to carry passengers. Diesel engine of Neptune-Polar type; constructed by the builders; trial trip, recently.

CATALOGUES.

POWER GAS CORPORATION, Ltd., Stockton-on-Tees.—Publication L.B. 1234 on lime burning plant.

GENT AND CO., Ltd., Leicester.—Particulars of the "Tangent" silent staff signalling system whereby lights are used instead of bells.

ROBERT BOBY, Ltd., Bury St. Edmunds.—Leaflet S.G.C. 201, showing recent installations of grain, seed, and cereal-handling plant.

HARLAND AND WOLFF, Ltd., Belfast.—Catalogue No. 349 of "Harland-B. and W." four-stroke stationary Diesel oil engines.

J. E. BATY AND CO., 39, Victoria-street, S.W.1.—A folder describing "Mercer" dial gauges for measuring and inspecting equipment.

RENOLD AND COVENTRY CHAIN COMPANY, Ltd., Manchester.—Publication No. 316/59, giving details of chain speed transformers.

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Loughborough.—Publications No. D 2 and D 3, dealing with horizontal Diesel engines.

BRITISH ALUMINIUM COMPANY, Ltd., Adelaide House, King William-street, E.C.4.—A 160-page book entitled "Aluminium Facts and Figures."

W. RICHARDS AND SONS, Ltd., Britannia Foundry, Middlesbrough.—The fifteenth annual issue of the firm's chart of iron and steel prices, 1914–1935.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The Continental Steel Trade and the Duties.

The iron and steel markets have passed through the confusion which naturally resulted from the somewhat abrupt advance in the import duties on foreign iron and steel, and it is now possible to visualise the chief features of the new situation. For some time before the duties were imposed there had been heavy buying of Continental steel. Most of this was bought on terms which permitted the consumer to cancel unrolled balances of the contracts, but obliged them to take any material already rolled when the duties were raised. As it turned out, many thousands of tons of Continental steel were awaiting shipment to this country at foreign ports on March 26th, but as there was at least as much again awaiting manufacture the position was obviously one for discussion. As a result of talks between the British consumers and Continental manufacturers an arrangement has been reached by which each will pay half of the increase in the duty, and consumers will refrain from cancelling their uncompleted balances. This is regarded as a fair compromise; but, of course, it is bound to affect the British market to some extent, since by admitting large quantities of Continental steel it will prevent the full effects of the increased duties being felt for a time. New business in Continental steel has been practically dead. Not only have the Continental works concentrated upon arranging their contracts, but they have shown no disposition to cut prices for the British market, and the present figure plus the higher duty has put new business out of the question. The devaluation of the Belga introduced a second disturbing factor into the steel markets, since it seemed possible that it would enable the Belgian steel works to reduce their prices. It has been announced, however, that there will be no alteration in quotations and that the Belgian steel works will maintain the Cartel prices which are based on gold. Whilst this removes at least for a time a danger which threatened the market, the position is not altogether satisfactory and may lead to fissures appearing in the Cartel organisation. The general view seems to be that much will depend upon the result of the discussions between the British Iron and Steel Federation and the Steel Cartel. It is generally believed that the Continent will then be prepared to accept a quota for the British market of 750,000 tons, which is about 100,000 tons more than the British have yet offered.

The Pig Iron Market.

The pig iron market has not been and is not likely to be affected by the increase in the duties except that the production of steel should be stimulated and the use of basic iron increased. Business in this class of iron has been on a good scale for a long period, and although imports from India appear to have fallen off of late there seems to be no decline in consumption. In fact, in some cases, works drawing supplies from their own furnaces are said to be running rather short. The situation in the foundry iron market has not changed much. The commencement of another month brought out a certain amount of business, but not sufficient to give the market a very active appearance. Generally speaking, buying has been confined to small parcels, but the deliveries against contracts give little cause for complaint. On the North-East Coast consumption appears to be little, if at all, below the production, but there has been a rather disconcerting absence of forward buying. It is suggested that consumers see no reason for placing forward orders when prices are so firmly stabilised; but, on the other hand, by buying they would assure themselves of supplies, and in the event of any sharp increase in the demand they would be protected from an increase in values. The Midland pig iron producers have not been selling their full production for some weeks, and for this they blame the limited demand from the light castings manufacturers. The turnover in March is estimated at rather less than that for February, and it is anticipated that buyers will be obliged to come into the market on a more extensive scale during the present month. In Lancashire the market keeps steady and a good tonnage of iron is passing into consumption week by week. Once or twice lately, however, there have been signs of the demand strengthening, but these have proved to be only temporary movements. The Scottish producers are well situated as regards contracts on their books, but the volume of new business shows a tendency to decline. The steel works' requirements of hematite in all districts were well maintained during March, but just recently deliveries have fallen off, particularly to some of the Midland districts.

Scotland and the North.

The confidence with which the Scottish iron and steel trades look forward to the future has been strengthened by the imposition of the higher duties on imported steel, which it is expected will improve the condition of all branches of the industry. For some time past the Scottish steel works have been operating at a high rate, and it is assumed that the re-rollers and some other departments which have not shared to the same extent as the steel makers in the improvement in trade will now reap a substantial benefit by the diversion of orders from the Continent. A considerable volume of business has recently reached the Scottish works from the locomotive and wagon manufacturers as a result of orders placed recently with those industries. The Scottish engineering concerns are also providing a good outlet for steel of various descriptions. The boilermakers are busier than they have been for a long time, and are taking good deliveries of plates—a section of the steel industry which for some months has experienced slack conditions. The constructional engineers have a number of good orders in hand, which include contracts for bridgework for foreign countries, and, in consequence, are using a large tonnage of structural material. The sheet industry, on the other hand, is working at well below capacity. There is a fair home demand for sheets from the motor vehicle makers, and from other consuming trades in this country; but the export side of the industry fails to show any sustained improvement. Now and again spasmodic buying by one or the other of the foreign markets raises hopes that better conditions have set in, but so far none of these movements have lasted. Recently the Scottish bar iron manufacturers have experienced an improved demand which has enabled them to keep their works in more regular operation. They complain, however, that the orders received, although more numerous, are for small tonnages. Forward buying, also, is the exception rather than the rule. In the Lancashire market there has been a strong demand for structural material. This has arisen probably as a result of the busy conditions at the constructional engineering works, which are not only well employed, but are meeting with a large inquiry for new work. Business in bright drawn steel bars and some of the lighter steel materials is steady, and a good business has been transacted during the past week or two in alloy and special steels.

The North-East Coast and Yorkshire.

The position of the steel works on the North-East Coast has been improved by the increased import duties, although the volume of business which has reached the works has not been so large as was anticipated before the announcement. Probably reports of a forthcoming advance in the duties which were current some time before it was announced were responsible for diverting a considerable tonnage of orders to the British works which would otherwise have been placed abroad, so that when the duties came into force there was not the same amount of new work available. Some of the re-rollers, however, rushed to cover their forward requirements of billets and sheet bars. The constructional engineers on the North-East Coast have been working on substantial contracts for some time past, but as most of these firms habitually use British steel, the change will not greatly improve the demand from this industry. Nevertheless, there has been a fair amount of new business placed during the past week for constructional steel which might or might not have been given out had the duties been left unaltered. The rail requirements of the home railways are keeping the mills well employed, and there are good prospects that the rate of production in this department will be maintained for some months. The home demand for sheets continues to take care of the greater part of the output, but this industry depends largely upon export business, which continues scarce. Most gauges of Continental sheets are outside the control of the Cartel, and it remains to be seen if the devaluation of the Belga will be reflected in cheaper prices even than those ruling of late. In the Yorkshire steel market some improvement has been noticeable during the past week, probably as a result of the higher duties. The actual effect of these, however, has not yet been felt, and steel makers, particularly those in the Sheffield district, look forward to a big expansion in demand. Business in basic open-hearth steel has revived somewhat, but the same cannot be said of the acid steel department. The re-rolling industry, of course, stands to gain by the higher duties and the strip makers already report a stronger demand. The production of special steel continues on a good scale, and the market shows no signs of becoming less active.

Current Business.

The London and North-Eastern Railway has placed an order for 3000 tons of rails with United Steel Companies, Ltd., Sheffield. A scheme for modernising the Newcastle-Tyneside Electric Railway at a cost of £400,000 is to be commenced shortly by the London and North-Eastern Railway. Russian orders placed in this country during February reached a total value of £1,121,282. The full value of the orders placed in the first two months of this year was £1,827,690. Included in the February total were machinery and equipment, £530,295; non-ferrous metals, £213,017; and alloys and steel, £36,977. David Brown and Sons (Huddersfield), Ltd., gear makers, who recently bought the premises at Penistone formerly occupied by the steel works of Cammell Laird and Co., Ltd., expect to put part of the works in commission in about six months time on the production of engineering products. The London, Midland and Scottish Railway announce that in connection with the company's permanent way renewal programme for 1935, contracts have been placed with British manufacturers for a total of 80,147 tons of steel rails. The following firms are participating in these contracts:—Barrow Hematite, 13,953 tons; British (Guest, Keen, Baldwin) Iron and Steel Company, 6489 tons; Cargo Fleet Iron Company, 3311 tons; Colvilles Ltd., 13,264 tons; Dorman, Long and Co., 5397 tons; Lancashire Steel Corporation, 8812 tons; Shelton Iron, Steel and Coal Company, 7134 tons; Skinningrove Iron Company, 2343 tons; Steel Company of Scotland, Ltd., 2196 tons; United Steel Company (Worthington Branch), 17,248 tons. The Department of Overseas Trade announce that the following contracts are open for tender:—Indian Stores Department, Engineering Section: buffer outer cases, &c. (New Delhi, April 22nd); galvanised corrugated and plain sheets required by the railways, two portable concrete mixers, petrol or oil driven, capacity not less than 7 cubic feet unmixed and 5 cubic feet mixed (New Delhi, April 24th); Argentine State Railways Administration: 4200 brake hose couplings without rubber washers, 2100 nipples for Westinghouse brake hose (1¼in.) (Argentina, May 2nd); Brazil, Rio Grande do Sul State Railways: steel bars (827 pieces), plates (46 pieces), angle plates (204 pieces) of various dimensions for bridge strengthening (Brazil, April 25th); Egypt, Ministry of the Interior: 610 lineal metres of 150 mm. diameter and 25 lineal metres of 80 mm. diameter centrifugally cast pipes, special castings, &c. (Egypt, April 17th).

A World Copper Arrangement.

The most important event in the copper market this week was the announcement of the terms of agreement between the copper producers who have been in conference at New York for the past three weeks. The market, of course, was prepared for an agreement and had some idea of the form it would take. The official announcement points out that the conference dealt exclusively with the foreign situation and did not consider production or sales within the United States, as the participants were excluded from that market by the American excise tax of 4c. per lb. of copper. The demand in foreign markets had improved during the past few months, but notwithstanding this recent production had been at a rate which would retard the liquidation of existing surplus stocks of copper and result in unsatisfactory prices. The copper companies represented at the meetings had an aggregate current production of 750,000 tons of copper per annum, or more than 75 per cent. of the total foreign primary production, excluding Russia and Japan. It was decided that a curtailment amounting to 240,000 tons of copper per annum from current production was to be made effective by June 1st. An organisation is to be created to compile statistical information so that while an adequate supply of copper will be provided at all times, the accumulation of excess stocks will be avoided. Uniform trade practices governing sales, deliveries, and terms of payment will be adopted, and while each producer reserves freedom of action within the above limitations there will be no pooling of sales or fixing of prices; but an effort will be made to ensure stable markets and avoid wide fluctuations in price. Whilst nothing is said in the official statement regarding the limitations of American exports, it is believed that these will be restricted to 8000 tons per month by a subsidiary "gentlemen's agreement." It is possible that fears of the American Anti-Trust Laws may be a reason why this important provision was relegated to the background. Naturally, on receipt of the news the copper market improved and buying in practically all departments became more active.

The Tin Market.

Uninteresting conditions have ruled in the tin market this week. Prices have been more steady as the result of the lack of interest shown by dealers than for any other reason. Business with the United States has been indifferent, and there has been only a poor Continental demand, the financial crisis in Belgium naturally having a tendency to check business. The March statistics provided no feature of particular interest. According to Mr. W. H. Gartsen the visible supply was reduced by 41 tons to 18,064 tons, compared with the figures at the end of February. There was a decline in the carry-over at the Straits from 1197 tons in February to 918 tons on March 30th, and the carry-over at the Arnheim smelter dropped from 2577 tons to 1831 tons. Taking into consideration the carry-over in the Straits Settlements and at the Arnheim smelter the visible supply would amount to 20,813 tons, or 1066 tons less than at the end of February. The total supplies during March showed a reduction of 3531 tons to 8049 tons, whilst the deliveries increased from 6756 tons for February to 8090 tons at the end of March. There is still a pronounced backwardation in this market, which shows that technically the prompt position is tight.

Average Non-ferrous Metal Prices.

The sharp change in the situation in the non-ferrous metal markets during March is illustrated by the official average prices for the month, issued by the London Metal Exchange. Until last month, when the prices of practically all metals showed a reduction as a result of the disturbance in the commodity markets, the tin quotation had alone remained firm for a long period. In March, however, tin was the one metal the average price of which showed a considerable fall. The quotation for cash copper advanced £1 7s. compared with the February average, and the three months average was £1 8s. 7d. better. The quotation for electrolytic was £1 8s. 4d. higher, wire bars £1 9s. 5d., and best selected £1 9s. 2d. over the previous month. In spite of the control exercised over the market and the efforts made to stabilise the price of tin, the average for cash tin during March was £11 12s. 1d. lower than in February, whilst for three months it was £11 18s. 6d. down. There was an increase in the lead price, the quotation for the current month shipment being 15s. 11d. higher, and for the third month following 15s. 6d. better than in February, whilst the mean was up by 14s. 8d. In spelter the improvement was not so noticeable and for shipment the current month the average quotation rose 5s. 6d. compared with February, for the third following month 5s., the mean being 5s. 3d. higher. The following are the official average quotations for March:—

Standard Copper		Cash	£28	11	0⅝
		3 Months	£28	18	2½
		Settlement	£28	10	11½
Electrolytic Copper			£31	16	10½
Electrolytic Wire Bars			£32	1	6½
Best Selected Copper			£31	9	2
Standard Tin		Cash	£215	19	5½
		3 Months	£211	17	1½
		Settlement	£215	18	9½
Lead	For shipment the current month		£11	0	2½
	For shipment the third following month		£11	3	9
	Mean		£11	1	11$\frac{13}{14}$
	Settlement		£11	0	4⅜
Spelter	For shipment the current month		£12	1	10⅝
	For shipment the third following month		£12	5	0
	Mean		£12	3	5⅜
	Settlement		£12	2	4½

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists 22s. 6d.; plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. Coast—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 8 6	3 2 0
No. 1	3 9 0	3 2 6
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 7 6	—
Midlands—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 11 0	
„ „ Forge	3 6 6	
Basic (*Less 5/– rebate*)	3 12 6	
Northampton—		
Foundry No. 3	3 7 6	
Forge	3 2 6	
Derbyshire—		
No. 3 Foundry	3 11 0	
Forge	3 6 0	
Scotland—		
Hematite, f.o.t. furnaces	3 11 0	
No. 1 Foundry, ditto	3 12 6	
No. 3 Foundry, ditto	3 10 0	
Basic, d/d (*Less 5/– rebate*)	3 7 6	
N.W. Coast—		
Hematite Mixed Nos.	3 12 6 d/d Glasgow; 4 0 6 „ Sheffield; 4 5 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
Lancs.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	
Best Bars	10 2 6	
S. Yorks.—		
Crown Bars	9 12 6	
Best Bars	10 2 6	
Midlands—		
Crown Bars	9 15 0	
Marked Bars (Staffs.)	12 0 0	
Nut and Bolt Bars	7 5 0 to 7 15 0	
Scotland—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. Coast—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

	Home.	Export.
London and the South—	£ s. d.	£ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 6	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	7 0 0
Flats, 5in. and under	8 14 6	7 0 0
Plates, ¾in. (basis)	9 0 0	7 15 0
„ ⅞in.	9 5 0	8 0 0
„ 1in.	9 10 0	8 5 0
„ 1⅛in.	9 15 0	8 10 0
„ 1¼in.	9 10 0	8 5 0
North-East Coast—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¾in.	8 15 0	7 15 0
„ ⅞in.	9 0 0	8 0 0
„ 1in.	9 5 0	8 5 0
„ 1⅛in.	9 10 0	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 5 0	8 5 0
Midlands, and Leeds and District—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ ⅞in.	9 2 6	8 0 0
„ 1in.	9 7 6	8 5 0
„ 1⅛in.	9 12 6	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 7 6 .. 7 15 0 to 8 5 0	

STEEL (*continued*).

	Home.	Export.
Glasgow and District—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 15 0	7 15 0
„ ⅞in.	9 0 0	8 0 0
„ 1in.	9 5 0	8 5 0
„ 1⅛in.	9 10 0	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates	9 5 0	8 5 0
South Wales Area—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ ⅞in.	9 2 6	8 0 0
„ 1in.	9 7 6	8 5 0
„ 1⅛in.	9 12 6	8 10 0
„ 1¼in.	9 10 0	8 5 0

Ireland—	Belfast. £ s. d.	Rest of Ireland. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¾in. (basis)	9 0 0	9 2 6
„ ⅞in.	9 5 0	9 7 6
„ 1in.	9 10 0	9 12 6
„ 1⅛in.	9 15 0	9 17 6
„ 1¼in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

	Home.	Export.
Sheets.	£ s. d.	£ s. d.
10-G. to 13-G., f.o.r.	9 0 0	8 15 0
14-G. to 20-G., d/d	10 5 0	9 0 0
21-G. to 24-G., d/d	10 10 0	9 5 0
25-G. to 27-G., d/d	11 2 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £16 12s. 6d., c.i.f. duty paid India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel Ports, 18/2 to 19/2.
Tin-plate Bars, d/d South Wales Works, £5 7s. 6d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 tons	5 15 0
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£21 15 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 10 0	7/–
„ „ 8 p.c. to 10 p.c.	£21 10 0	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/–
„ „ „ 1 p.c. carbon	£36 5 0	11/–
„ „ „ 0·70 p.c. carbon	£37 5 0	12/–
„ „ „ carbon free	9¼d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 15 0 scale 5/– p.u.	
„ „ 75 p.c.	£17 17 6 scale 6/– p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	4/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Cobalt	5/– to 5/6d. per lb.	

NON-FERROUS METALS.

Official Prices, April 3rd.

Copper—	
Cash	£30 5 0 to £30 6 3
Three months	£30 13 9 to £30 15 0
Electrolytic	£33 15 0 to £34 5 0
Best Selected Ingots, d/d Birmingham	£34 5 0
Sheets, Hot Rolled	£60 0 0
	Home. Export.
Tubes, Solid Drawn (basis)	9¾d. 9¾d.
„ Brazed (basis)	9¾d. 9¾d.
Brass—	
Ingots, 70/30, d/d Birmingham	£26 0 0 to £28 0 0
	Home. Export.
Tubes, Solid Drawn, 2/1 Alloy	9d. 9d.
„ Brazed	11d. 11¼d.
Tin—	
Cash	£217 10 0 to £218 0 0
Three months	£214 15 0 to £215 5 0
Lead	£11 13 9 to £12 0 0
Spelter	£12 3 9 to £12 10 0
Aluminium Ingots (British)	£100

FUELS.

SCOTLAND.

Lanarkshire—	Export.
f.o.b. Grangemouth—Navigation Unscreened	13/– to 13/6
„ Glasgow—Ell	16/6
„ „ Splint	17/6
Ayrshire—	
(f.o.b. Ports)—Steam	14/– to 14/6
Fifeshire—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	13/6 to 14/–
Unscreened Navigation	12/6 to 13/–
Lothians—	
(f.o.b. Leith)—Hartley Prime	13/6 to 13/9
Secondary Steam	13/– to 13/3

ENGLAND.

Yorkshire, Manchester—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	15/– to 17/6
Northumberland, Newcastle—	
Blyth Best	14/3 to 14/9
„ Second	13/3
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
Durham—	
Best Gas	14/8
Foundry Coke	19/– to 20/–

Sheffield—	Inland.
Best Hand-picked Branch	24/– to 26/–
South Yorkshire Best	21/– to 23/–
South Yorkshire Seconds	17/6 to 19/–
Rough Slacks	8/– to 9/–
Nutty Slacks	7/– to 8/6

SOUTH WALES.

Cardiff— Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	13/6 to 14/–
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	24/– to 37/6
Furnace Coke	19/– to 21/6
Patent Fuel	21/–
Swansea—	
Anthracite Coals:	
Best Large	36/– to 40/–
Machine-made Cobbles	41/– to 48/6
Nuts	40/– to 48/6
Beans	25/– to 30/–
Peas	19/– to 22/6
Rubbly Culm	10/6 to 11/–
Steam Coals:	
Large	18/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

Manchester prices ¼d. per gallon extra.

French Engineering Notes.

(From our own Correspondent in Paris.)

Trade Reactions.

THE withdrawal of Belgium from the gold group has reacted unfavourably on trade in this country, where everyone is anxiously waiting to see what is going to happen next. Competition from lower-priced Belgian goods is practically averted by the import quotas, but the mechanical engineering trades are asking for further restrictions, principally on account of the competition from Germany, which is particularly favoured by the system of basing quota allocations on the reference period of 1932, and it is complained that German goods are offered at inexplicably low prices. Some machinery makers affirm that if their demand for reduced quotas is not acceded to they will have to close down. In a general way, the Government is not disposed to tighten up import restrictions, and until recently it showed a tendency to relax them, but in a case of emergency it is not impossible that there may be some manipulation of quotas on a small scale, if it can be done without risk of reprisals. On the other hand, some branches of engineering are benefiting from orders given out for work of national defence.

The Navy.

In defending the demand for credits amounting to 1065 million francs for the putting in hand this year of a 35,000-ton battleship and two torpedo boats of 1700 tons, to be followed early in 1937 by a second battleship, the Minister of Marine, Monsieur Pietri, made the first official declaration of a change of policy that had been for some time inevitable. The Superior Council of the Marine never abandoned the idea of battleships constituting the necessary backbone of a fleet, but it was over-ruled more or less by Governments and Parliamentary Naval Commissions which continued to hand down traditions of the light surface craft policy initiated by Admiral Aube and reinforced after the war by the submarine. It was for this reason that France accepted the limitations imposed upon the total tonnage of battleships by the Washington Conference, which she has since regretted. The French first line now consists of the old battleships "Courbet," "Jean-Bart," and "Paris," which are regarded as obsolete, and the 22,000-ton battleships "Bretagne," "Lorraine," and "Provence," with ten guns of 340 mm., which only completed their armament after the outbreak of the war. The old ships will soon give way to replacement, and the "Dunkerque" and "Strasbourg" are regarded as substitutes for the "Jean-Bart" and the "France," which latter ship struck a rock and sank in the Teignouse channel off Brest in 1922. The "Provence" was transformed last year, when her machinery was replaced by turbines and oil-fired generators and protection was provided against air attack. Her speed trials were satisfactory, and the sister ships are being transformed in the same way. Now that France possesses more submarines than she really needs, and finds that they are relatively costly to build and maintain, she is concentrating on heavier ships. It was expected that the 25,000 tons of the "Dunkerque" and "Strasbourg" would have represented a maximum, but the new Italian battleships left this country with no alternative but to put two ships of 35,000 tons on the stocks. During the debate in Parliament Monsieur Pietri disposed of criticism by declaring that the construction of the battleship would provide employment for 16,000 men for four years, including those engaged upon it in private industry.

The "Normandie."

The Compagnie Générale Transatlantique embarked upon the construction of the "Normandie" at a time when traffic was still sufficiently good to justify the belief that a ship offering advantages in convenience and speed would be able to pay her way. A ship of her length and speed would, it was thought, convey to passengers the illusion of living in a hotel rather than of travelling on the sea. Now that the "Normandie" is to start on her maiden voyage next month under conditions that will necessarily involve a heavy financial deficit it is claimed that the State should make good all losses, for it was the Government which insisted on the company building the ship with the object of raising the prestige of the merchant marine, and as prestige is the only positive result likely to be achieved by running the ship in these difficult times, when freights are heavily against French shipping, the whole of the financial burden should, it is urged, be borne by the State. The cost of building the "Normandie" was covered by loans guaranteed by the State, and it is now intended to introduce into Parliament a Bill to authorise the State to take up those loans so as to relieve the Compagnie Générale Transatlantique of a charge amounting to more than 800 million francs.

Small Refuse Incinerators.

Some years ago the Superior Council of Health prepared a programme of tests of refuse destruction plants for small towns and communes, but nothing came of it, and refuse has continued to be dumped outside towns and villages. Since that time local prejudice against incineration has been removed by a better knowledge of methods that avoid public inconvenience. In the Department of the Seine-et-Oise a meeting of municipal bodies has been held to discuss the problem in the light of engineers' reports upon the possibility of installing small plants, with the high temperatures obtained nowadays, suitable for the economic destruction of a minimum of 25 tons of refuse a day. Opinion was unanimously in favour of towns having incineration stations and of the communes combining to send their collective refuse to a central station, but the towns and communes hesitated to embark upon the financial responsibility of constructing and exploiting such installations, and it was suggested that they should contract with companies for the disposal of refuse. Already a number of towns have incineration plants, but a general extension of the system will obviously be retarded by financial considerations, unless private enterprise can organise profitably the destruction of refuse on a small scale. This problem is still awaiting solution, for there is nothing yet that will give satisfaction to towns and communities where economy is of the first importance.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

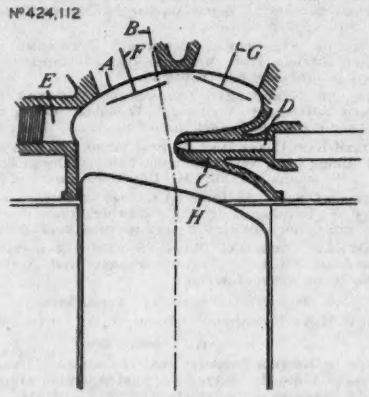
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

424,112. May 31st, 1934.—COMBUSTION HEADS, S. Witkowski, 32, Chemin de Grande-Canal, Geneva, Switzerland.

This combustion chamber takes the form of a space generated by an elipse A, the minor axis of which is set at an angle to the bore of the cylinder, as shown at B. It is partially cut off from

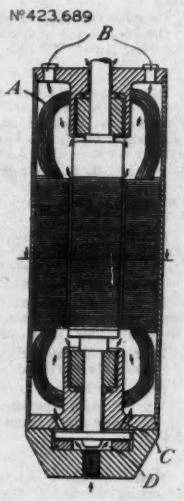


the working cylinder by the wall C, in which the fuel injection nozzle D is arranged. The sparking plug is indicated at E, the air inlet valve at F, and the exhaust valve at G. The top of the piston H is shaped to conform, more or less, to the contour of the wall C.—*February 14th, 1935.*

DYNAMOS AND MOTORS.

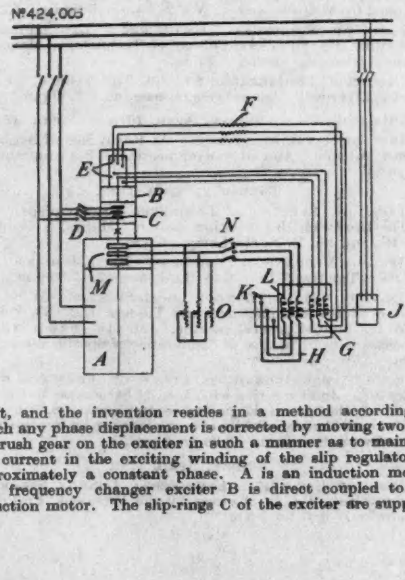
423,689. November 30th, 1933.—ELECTRIC MOTORS, Worthington-Simpson, Ltd., of Lowfield Works, Newark-on-Trent, and Société de Participation Financiere Electric Pump, of 5, Rue Philippe, Luxembourg.

This invention relates to electric motors of the submersible type, and is especially applicable to induction motors particularly of the cage type. The windings A are composed of wire having specially heavy or reinforced insulation and adapted to resist for an indefinite period the action of the liquid (such as water or petroleum) in which it is proposed to immerse the motor. Two, three, or more filters B are fitted to the upper cover. The lower cover is provided with passages C affording communication between the chamber D and the interior of the motor. The arrangement provides for the flooding of all parts of the motor by the liquid in which it is immersed, and which has been filtered prior to admission and serves to maintain lubricating films in all parts subject to friction. In order to reduce the initial current surge at starting in the case of squirrel-cage rotors the motor is preferably provided with an automatic starting device, which is also described.—*February 6th, 1935.*



424,005. August 14th, 1933.—SPEED CONTROL OF ELECTRIC MOTORS. The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2. and Bernard Adkins, of 13, Fisher-avenue, Paddox, Rugby.

This invention is concerned with a variable-speed induction motor having associated therewith a separate slip regulator excited from a frequency changer exciter on the main motor

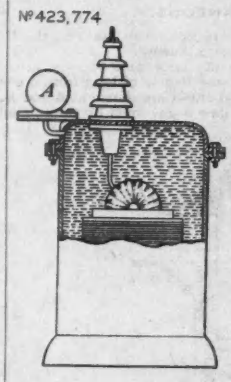


shaft, and the invention resides in a method according to which any phase displacement is corrected by moving two sets of brush gear on the exciter in such a manner as to maintain the current in the exciting winding of the slip regulator at approximately a constant phase. A is an induction motor. The frequency changer exciter B is direct coupled to the induction motor. The slip-rings C of the exciter are supplied through a switch D, and the two brush rings E on the commutator of the exciter are connected in series with the fixed resistance F and the exciting winding G of the slip regulator. The separate slip regulator set comprises the slip regulator H and the driving motor J. The commutator K of the slip regulator in series with the compensating winding L on the stator is connected to the slip-rings M of the main motor through the switch N. When starting up, the main motor is run up to speed by means of the starting resistance O, after which the switch N is closed and the starter O open circuited. The speed of the main motor can be varied above and below synchronous speed in the same way as the Schrage variable-speed motor by moving the two brush rings on the exciter relative to one another. In order to maintain the power factor of the equipment within reasonable limits without producing excessive losses in the field resistance F, the two brush rings E on the exciter are geared together by means of pinions of unequal size. If S be the slip of the main motor, both the flux and the frequency in the slip regulator are approximately proportional to S, and the quadrature voltage in the exciting winding is proportional to S^2. If the exciter brush gear is at the neutral position when the two sets of brushes are together at synchronous speed, the angular shift at other speeds is proportional to S. The quadrature component of the exciter voltage is therefore approximately proportional to $S \times \sin K S$, or $K S^3 - \frac{K^3 S^4}{6}$, where K is a constant, and is very close to the value required unless the angle K S is large.—*February 13th, 1935.*

TRANSFORMERS AND CONVERTERS.

423,774. April 28th, 1934.—COOLING COMPOSITIONS FOR ELECTRIC APPARATUS, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.

In accordance with this invention sludge precipitation occurring in insulating oil is retarded and the insulation properties and fluidity of the oil are preserved by maintaining organic polycarboxylic acid, or an anhydride thereof, in contact with or dissolved in the oil during its use in electrical devices, such as transformers. The tank is completely filled with mineral hydrocarbon oil which, when expanding, flows into the conservator A. A polycarboxylic acid, in contact with the oil, retards sludging as above stated even in the presence of copper. It also prevents a decrease in insulation characteristic and a rise of the power factor in oils when subjected to electric stresses over long periods of time. Polycarboxylic acids may act to increase the solubility of the sludge in the oil, or as a negative catalyst or retarder of chemical changes which produce acidity or otherwise deteriorates the oil.—*February 7th, 1935.*



423,618. October 25th, 1933.—ELECTRIC TRANSFORMERS AND CHOKING COILS, Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt.

The object of this invention is to suppress the harmonics in the saturated iron core transformers or choking coils. Two saturated three-phase choking coils A and B are shown which are connected to alternating current mains. The choking coils have a common iron core structure upon the limbs of which the different windings of the coils are arranged, the limbs for the winding of each coil being arranged adjacent to one another in a row and having a common yoke, and the limbs of one of the two sets of three being aligned with the limbs of the other set as shown. The windings of the first choking coil are connected in open star arrangement and those of the second choking coil in zig-zag, so that the fundamental waves of the fluxes in two aligned limbs are displaced by 30 electrical degrees with respect to each other. The cores of the choking coils are provided with a supplementary limb, so that the harmonics divisible by three can be formed in the flux. In this way the curve

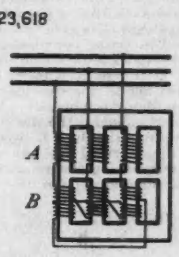


Fig. 1

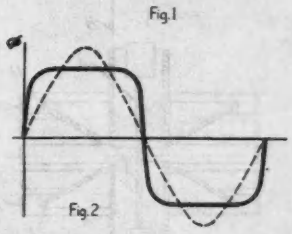


Fig. 2

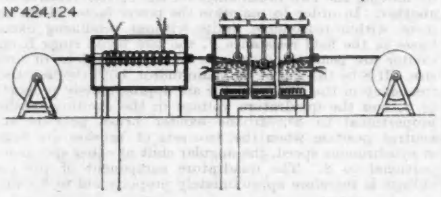
diagram of the flux becomes rectangular, as is shown by the thick full line in the graph of Fig. 2, and a relatively high amplitude of the fundamental wave is obtained, the curve of which is also shown in broken lines in Fig. 2. On the other hand, the result is attained that the curves of the phase potential of the separate choking coils or transformers show two marked peaks in the potential, one in the positive half-wave and one in the negative half-wave, as is known in the excitation of highly saturated single-phase choking coils when excited with current of sine form. The potential peaks of the separate phase potentials are displaced by 30 deg. with respect to each other. Since for the grid control of ionic valves of all kinds, for example, controlled rectifiers, in triple, six-fold, and multiple-phase connections, grid potentials with strongly marked peaks are particularly favourable for effecting the ignition of the separate anodes controlled by the grids, these phase potentials of the transformers are consequently very suitable for the exciting potential of the grids controlling such tubes.—*February 5th, 1935.*

METALLURGY.

424,124. May 15th, 1933.—A Process for Thermally Hardening Steels, *R. E. Ellis*, 70, *Chancery-lane, London, W.C.2.*

This process is one of thermally hardening carbon and alloy steels which comprises quenching the same from a temperature above the critical temperature range to a temperature below the temperature of rapid pearlite formation, but above that at which rapid conversion of austenite to martensite is obtained, and in thereafter maintaining the quenched steel at a temperature above the temperature of rapid martensite forma-

No 424,124



tion and below the temperature of rapid pearlite formation for a time interval at least sufficient to obtain conversion of the austenite to crystal structures other than pure martensite, characteristic for the temperature of heat treatment, and then cooling to atmospheric temperatures. The plant for carrying out the process in the case of wire or strip is indicated in the drawing. It comprises an electrically heated furnace and an electrically heated quenching bath, the temperatures of which are controlled by thermostats. The specification includes graphs showing the progress of hardening of several alloy steels.—*February 15th*, 1935.

MISCELLANEOUS.

423,204. October 4th, 1933.—Gas Control Valves, H. H. Greaves, Sunnyside, Newdigate, Surrey.

This valve is said to be specially applicable to type metal casting machines, in which a precise degree of heat from a gas burner is required. The inlet and outlet are shown at A and B, respectively. The extent of the flow is governed by the conical

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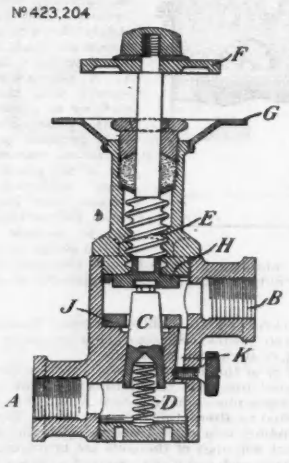

plug C, which can be depressed against the spring D by the screwed spindle E. This spindle is equipped with a graduated disc F that, in combination with the fixed disc G, enables the setting of the valve to be determined. In the completely closed position the flange H presses down on the rubber washer J. A by-pass is provided at K.—*January 28th*, 1935.

423,702. April 23rd, 1934.—Electron Discharge Devices. The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.

According to this invention, an electron discharge device adapted for the operation by the diversion of an electron stream, which is emitted substantially in a plane transverse to the axis of the cathode of the device, has a control electrode or electrodes to which are applied diverting potentials. A number of ring-shaped receiving electrodes are coaxially arranged around the cathode. A is an incandescent wire with supports B. C is a cylindrical divided anode, the two halves of which may be connected to one another mechanically. D and E are the control electrodes, which influence the direction of movement of the electrons issuing from the slit F between the anode sections in consequence of the electrical field prevailing between them. G to H are annular receiving electrodes which, in accordance with the value and direction of the diverting voltage applied

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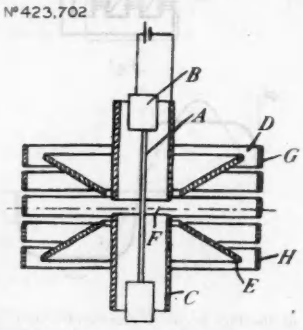

to the control electrodes D and E are selectively bombarded by the electron stream. The control electrodes in the form of frusto-conical discs (or annular discs or rings) are preferably so constructed that the electrical lines of force of the diverter field intersect the path of the electrons vertically at all points as far as possible. Surfaces with a double bend may, of course, be found suitable in this connection. If the voltages applied to the receiving electrodes G–H are so great that a field strength is obtained at the incandescent wire which will ensure the emission of the electron at right angles to the surface of the wire, the slit anode C may in some cases be omitted. In such cases all the receiving electrodes will, however, carry a small current, which is due to the slight part of the emission supplied by the parts of the cathode surface located outside the centre of the incandescent wire. If, in addition to the change in direction of the electron stream, a change in its current strength is also desired, a control grid may be employed in a known manner.—*February 6th*, 1935.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

To-day.

Inst. of Electrical Engineers: Meter and Instrument Section.—Savoy-place, W.C.2. "A Valve Ammeter for the Measurement of Small Alternating Currents of Radio Frequency," and "A Permanent-magnet Device for Enabling a more Uniform Division of the Scale of Alternating-current-indicating Instruments to be Readily Obtained," Dr. H. M. Barlow. 6.30 for 7 p.m.

Inst. of Mechanical Engineers.—Storey's-gate, S.W.1. Informal meeting. Discussion, "The Use of Needle Roller Bearings." Opening speaker, Mr. C. G. H. Richardson. 7 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Informal meeting. "Some Aspects of Cement Testing," Mr. R. P. Mears. 7.30 p.m.

Inst. of Structural Engineers: Midland Counties Branch.—James Watt Memorial Inst., Birmingham. Tenth annual general meeting. 6.30 p.m.

Inst. of Structural Engineers: Western Counties Branch.—Merchant Venturers' Technical College, Bristol. Members' night and Branch annual meeting. 7.15 p.m.

North-East Coast Inst. of Engineers and Shipbuilders.—At Mining Inst., Newcastle-upon-Tyne. "Ocean Transportation of Petroleum in Bulk," Mr. Robert F. Hand. 6 p.m.

Physical Soc.—At Imperial College of Science and Technology, S. Kensington, S.W.7. Editing Committee meeting, 3.30 p.m.; Council meeting, 4 p.m.; meeting, 4.45 for 5 p.m.

Railway Club.—At Royal Scottish Corporation Hall, Fetter-lane, E.C.4. "Railway Stations and Architecture," Mr. R. M. Robbins. 7.30 p.m.

To-day to Thursday, April 18th.

Ideal Home Exhibition.—Olympia, W. Open daily.

Saturday, April 6th.

Inst. of British Foundrymen: Lancashire Branch.—At Engineers' Club, Manchester. Annual general meeting. Paper, "Some Notes on the Production of Steel Castings," Mr. J. E. Mercer. 3.30 p.m.

Monday, April 8th.

Chartered Surveyors' Inst.—12, Great George-street, S.W.1. "The State of Aviation in Great Britain, with special reference to its Effect on Property and Questions Connected Therewith," Mr. Nigel Norman. 6.30 p.m.

Inst. of Civil Engineers: Belfast and District Assoc.—Queen's University, Belfast. Institution Lecture to Students, "Modern Methods and Plant for Excavation," Sir Henry Japp. 6.30 p.m.

Inst. of Electrical Engineers: North-Eastern Centre.—Armstrong College, Newcastle-upon-Tyne. Annual general meeting. Paper, "The Droitwich Broadcasting Station," Messrs. N. Ashbridge, H. Bishop, and B. N. MacLarty. 7 p.m.

Stephenson Locomotive Soc.—King's Cross Station, N.1. "The Production of a Locomotive from Preliminary Schemes to the Trial Run," Mr. Eric Forge. 6.30 p.m.

Tuesday, April 9th.

Illuminating Engineering Soc.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. Symposium on "Lighting." Papers, "A Works' Photo-electric Method for the Photometry of Electric Discharge Lamps," Mr. P. D. Oakley; "A Simple System for Recording and Displaying Measurements of Illumination," Mr. R. R. Holmes; "The Use of Scale Models in Illuminating Engineering," Mr. H. S. Barlow; and "Practical Considerations in Architectural Lighting," Mr. H. Lingard. 6.30 p.m. for 7 p.m.

Inst. of Electrical Engineers: Scottish Centre.—At 39, Elmbank-crescent, Glasgow, C.2. Annual general meeting. Paper, "The Droitwich Broadcasting Station," Messrs. N. Ashbridge, H. Bishop, and B. N. MacLarty. 7.30 p.m.

Inst. of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow, C.2. "Brittleness in Engineering Materials," Mr. W. E. Lewis. 7.30 p.m.

Inst. of Marine Engineers.—85/88, The Minories, E.C.3. "Modern Marine Condensing Plants and Feed Systems," Mr. H. Hillier. 6 p.m.

Manchester Geological and Mining Soc.—Visit to works of the Lancashire Steel Corporation, Irlam, near Manchester. 2.45 p.m.

Wednesday, April 10th.

Inst. of Civil Engineers.—Great George-street, S.W.1. Informal meeting. Discussion, "The Economic Outlook for Engineering," Mr. J. L. Hodgson. 6 p.m.

Inst. of Electrical Engineers: Transmission Section.—Savoy-place, W.C.2. "The Effect of Legislation and Regulations upon Electricity Distribution," Mr. W. Fennell. 5.30 for 6 p.m.

Inst. of Fuel.—At Chemical Soc., Burlington House, W.1. "Processing of Solid and Liquid Hydrocarbons in the Coal, Oil and Gas Industries, with reference to Developments at Corby," Mr. Alfred Fisher. 6 p.m.

Inst. of Naval Architects.—Grand Hall, Connaught Rooms, Great Queen-street, W.C.2. Annual dinner. 7.30 p.m.

Inst. of Structural Engineers: Lancashire and Cheshire Branch.—At College of Technology, Manchester, Annual business meeting. 7 p.m.

Liverpool Engineering Soc.—9, The Temple, 24, Dale-street, Liverpool. Annual general meeting. 6.30 p.m.

Wednesday to Friday, April 10th to April 12th.

Inst. of Naval Architects.—At Royal Soc. of Arts, John-street, Adelphi. Annual general meetings. For programme see page 337.

Thursday, April 11th.

Inst. of Electrical Engineers.—Savoy-place, W.C.2. "The Droitwich Broadcasting Station," Messrs. N. Ashbridge, H. Bishop, and B. N. MacLarty. 6 p.m.

Inst. of Mechanical Engineers.—Hotel Metropole, Leeds. "Diesel Traction," Prof. G. V. Lomonossoff. 7.30 p.m.

Inst. of Metals: London Local Section.—At Rooms of Soc. of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W.1. Annual general meeting. Mr. C. Dresser will open discussion on "The Use of Significance of Specifications." 7.30 p.m.

Societe des Ingenieurs Civils de France: British Section.—Joint meeting with Inst. of Structural Engineers, at Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "The Reinforced Concrete Bridge over the Seine at La Roche-Guyon," Monsieur S. Boussiron. 5.30 for 6 p.m.

Friday, April 12th.

Inst. of Electrical Engineers: London Students.—Savoy-place, W.C.2. Address by the President, Prof. W. M. Thornton. 6.30 for 7 p.m.

Inst. of Mechanical Engineers.—Storey's-gate, S.W.1. Extra general meeting. Discussion, "Aerodynamical Research and Hydraulic Practice," Mr. A. Fage. 6 p.m.

Inst. of Sanitary Engineers.—At Caxton Hall, S.W.1. "The Manufacture of Concrete and Stoneware Pipes and their Uses," Mr. Cyril Poole. 6 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. "Art and Industry in Scandinavia," Mr. C. H. G. Aston. 7.30 p.m.

Monday, April 15th.

Inst. of Civil Engineers: Belfast and District Assoc.—Queen's University, Belfast. "The Preparation of Estimates for Public Works," Mr. F. C. Fforde. 6.30 p.m.

Engineers' German Circle.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "The New Bridge over the Little Belt," Dr. Ing. e.h.o. Erlinghagen. 5.15 for 6 p.m.

Royal Aeronautical Soc.—At Inst. of Electrical Engineers, Savoy-place, W.C.2. "Commercial Aircraft," Captain C. de Havilland. 6.30 p.m.

Wednesday, April 17th.

Inst. of Locomotive Engineers.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. General meeting. 6 p.m.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.

The Summer Meeting of the Institution of Automobile Engineers will be held jointly with members of the Société des Ingénieurs de l'Automobile of Paris, from Thursday, May 30th, to Saturday, June 1st, 1935. The meeting will take the form of a tour from London to the Midlands, thence to Oxford, and back to London. Visits to works have been arranged as follows:—Thursday morning: The Austin Motor Company, Ltd., Northfield, Birmingham; Alfred Herbert, Ltd., Coventry. Afternoon: The Daimler Company, Ltd., or Messrs. Humber, Ltd. On Thursday evening, a banquet will be held in the Welcombe Hotel, Stratford-on-Avon. On Friday morning, motor coaches will convey delegates from Stratford-on-Avon to Oxford, where they will inspect the Cowley Works of Morris Motors, Ltd. The afternoon visits will be to: The Pressed Steel Company, Ltd., the M.G. Car Company, Ltd., or a tour of the University Buildings. The delegates will return to London on Friday evening. On Saturday various visits will be arranged. Full particulars of the meeting may be obtained from the Secretary of the Institution of Automobile Engineers, Watergate House, Adelphi, W.C.2.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

Crossley Brothers, Ltd., inform us that their London address is now Bush House, Aldwych, London, W.C.2. Telephone, Temple Bar 5846.

A. Arnold and Co., sports and stop watch manufacturers, of 122, St. John-street, have removed to larger premises at 19, Clerkenwell-road, London, E.C.1.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

The Hunslet Engine Company, Ltd., Leeds, has received an order from the Crown Agents for the Colonies for three tank shunting locomotives, 0–8–0 type, 3ft. 6in. gauge, cylinders 18in. by 23in., for the Gold Coast.

The Liverpool Refrigeration Company, Ltd., has received a further order for refrigerating plant for the Hull Ice Factory, which will include a four-cylinder vertical sleeve valve compressor operating on the supercharged principle, and three horizontal multi-pass ammonia condensers and horizontal heat interchangers.

The Sturtevant Engineering Company has recently received orders for electrostatic precipitators from the Leicester, Nottingham, and Leeds Electricity Departments. The precipitator for Leicester is to be used in conjunction with a boiler of an evaporation of 230,000 lb. of steam per hour; the contract for Nottingham consists of four precipitators, each working in conjunction with a powdered fuel fired boiler of 200,000 lb. per hour evaporation; and the Leeds precipitator is to work with a powdered fuel fired boiler of an evaporation of 230,000 lb. of steam per hour.

"The Leyland Journal," Vol. I, No. I.—We have just received from Leyland Motors, Ltd., of Leyland, Lancs, the first number of the *Leyland Journal*, a publication designed to let operators of the firm's productions know what is happening at the factories, and to allow an interchange of experiences. It is hoped that the new magazine will be helpful about the traffic, legal, and engineering aspects of the operation of goods vehicles, buses, coaches, trollybuses, fire engines, and railcars.

Safety Screw.—In order to prevent pilferage, from railway rolling stock, for example, Craftplugs, Ltd., of Thames House, Millbank, S.W.1, are producing an ingenious form of screw which cannot be removed easily after it has been driven. A sample before us is a usual countersunk screw for wood. In the centre of the slot a short hole is drilled downwards into the shank. In this condition the screw can be driven by a screw driver. The protecting device consists of a steel dome provided with a stalk which is a driving fit in the drilled hole. When the dome is driven home with a blow of a hammer the slot in the screw head is completely covered. To remove a dome it is necessary to drill a hole through its centre until a neck on the stalk is separated.

A New Trigonometrical Slide Rule.—In the closing paragraph of the article on Messrs. A. G. Thornton's new trigonometrical slide rule, which appeared in our issue of March 22nd, we stated that calculations of the form $p \sin \alpha \tan \beta$ could not be performed on it without intermediate readings and re-settings. This statement, we find, is incorrect. Calculations of this form can be effected by a continuous series of operations without intermediate readings. The process involved is simple and direct. The cursor line is set to p on the D scale, the slide is moved to bring α on the S D scale to the cursor line, the cursor is moved to α on the C scale, the slide is moved to bring β on the T D scale to the cursor line, the cursor is moved to β on the C scale and the answer is read at the cursor line on the D scale. If β exceeds 60 deg.—the limit of the T D scale—the calculation is transformed into the form $p \sin \alpha \div \tan \theta$, where θ is the complement of β. While we regret having made a wrong statement on this point, we are happy to call attention to it. Our error illustrates the fact that a prolonged study, such as we gave to the rule, is not sufficient to exhaust its higher possibilities, and that the more thoroughly one becomes acquainted with it the more will one find in it features of value and interest.